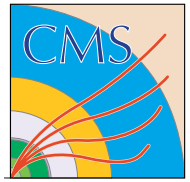


Status of HB TB2002 data analysis

Shuichi Kunori

Jordan Damgov

04-Dec-2002

All results are preliminary!

HB Testbeam 2002

Dates:

- June 26-July 1 "ECAL" // July 24-July 31 HF // Aug. 01- Sep. 18 HB

Goals (HB):

- Demonstrate 144ch working
- Demonstrate DCS going
- Source data vs GeV/ADC (beam: e / μ / π)
- Muon signal in HO for muon trigger
- Eta dependence (attenuation)
- Eta dependence (timing)
- Pulse shape (needs TDC)
- Weight in Layer 0

→ start construction of Calibration Database

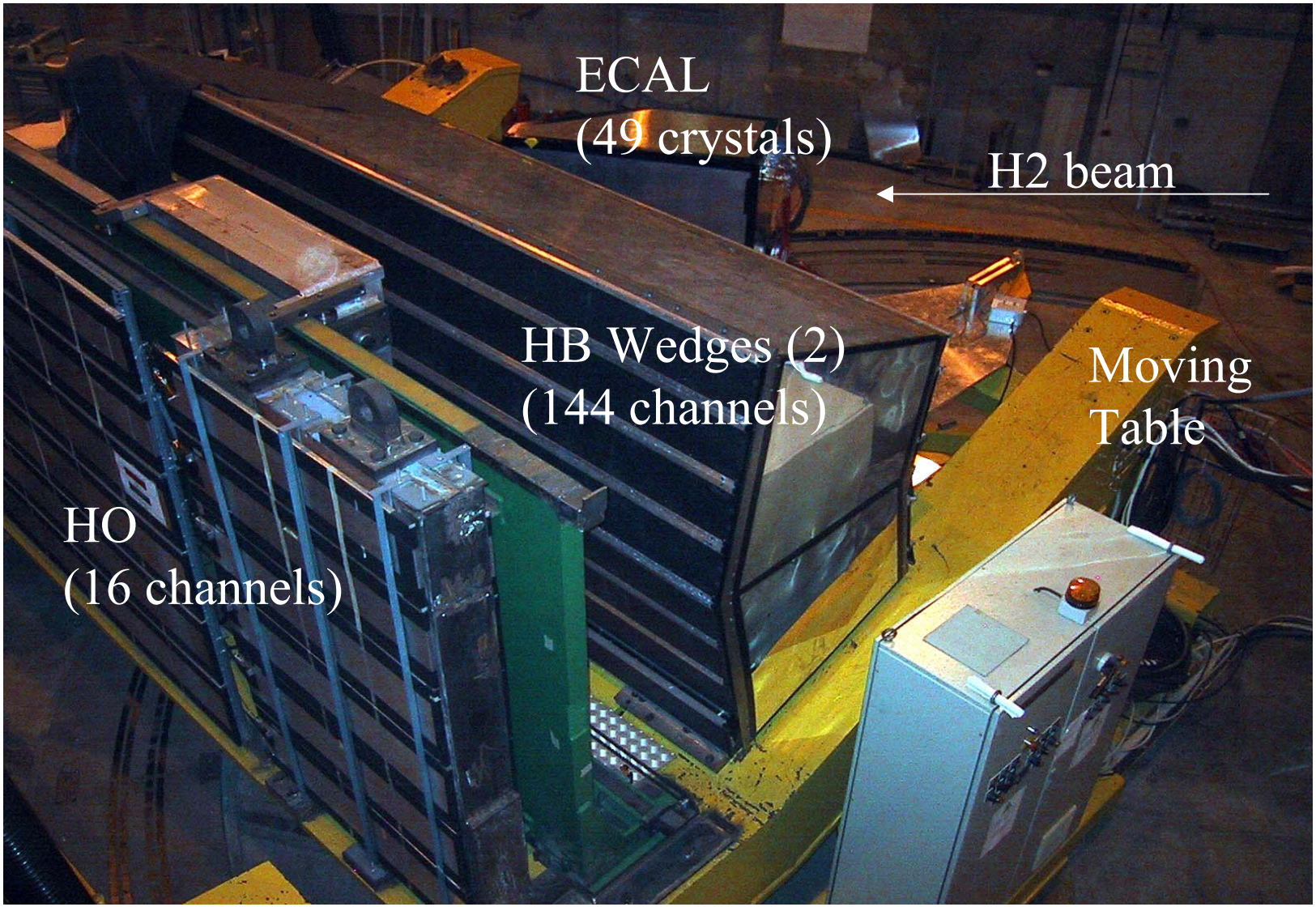
Additional Goals (left over from 1999TB)

- Crack between wedges
- e/pi (resolution and linearity)
- Cerenkov light in clear fibers

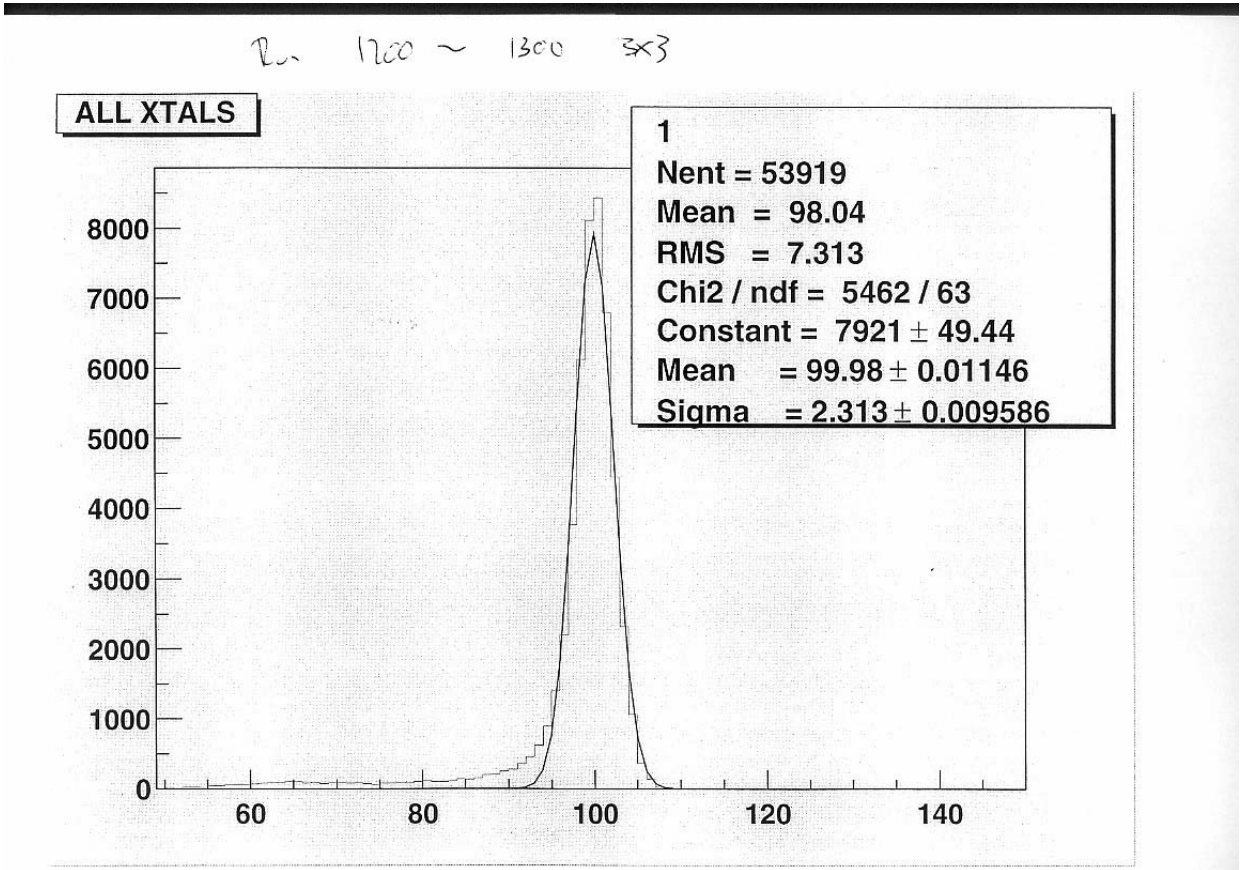
HCAL+"ECAL" Layout

Calibrate 4 wedges ′02. Check HO response as tail catcher and as muon trigger element. In ′03 use PPP to study 40 MHz beam and HE/HB transition region.

Testbeam Layout



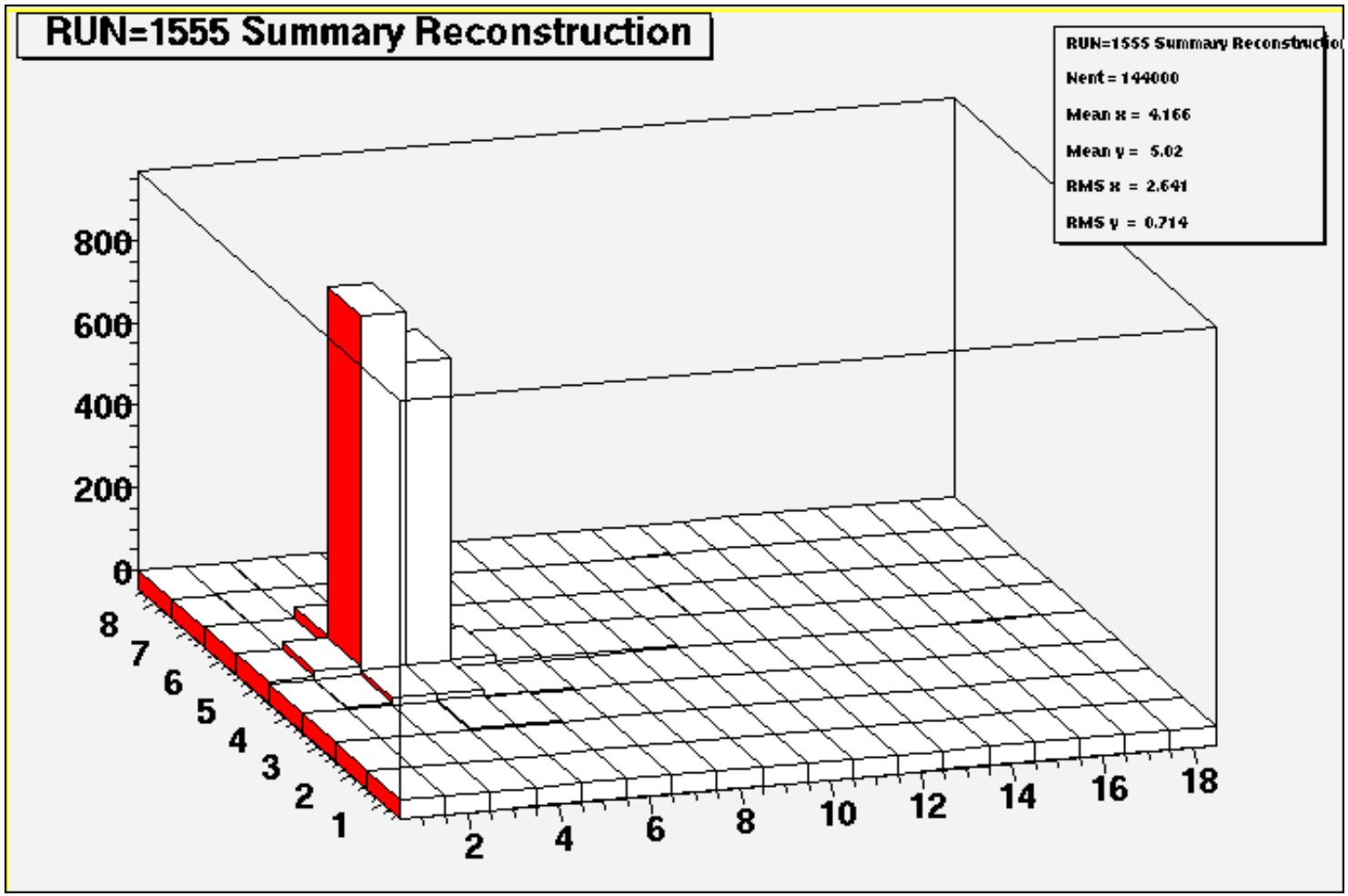
"ECAL"



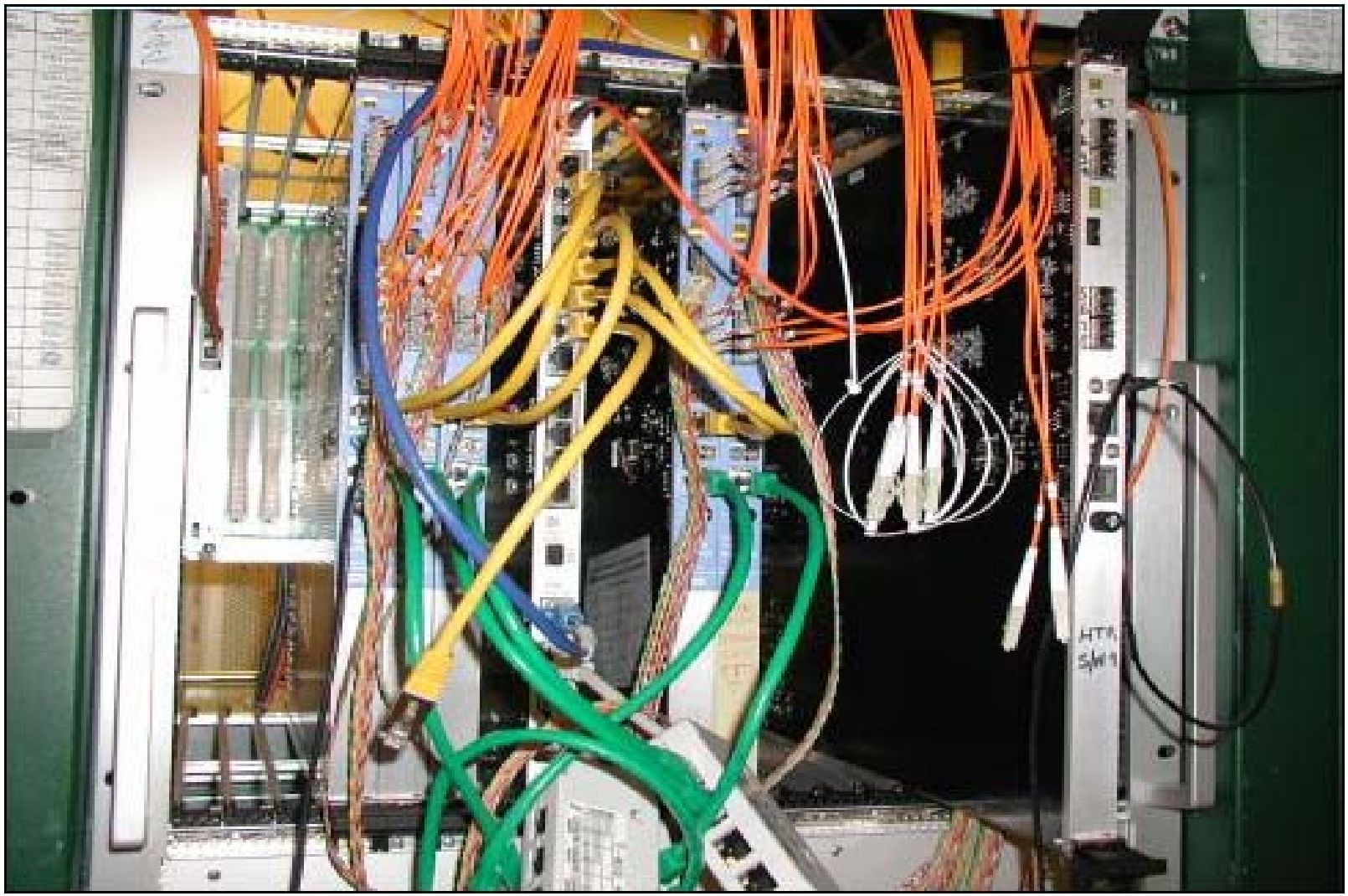
Have a 7 x 7 crystal array in front of HCAL which can be moved for eta scan. Online get a usable resolution of 2.3 %.

HB 2 Wedges - 16η x 8ϕ

300GeV π^-



Prototype HTR , DCC



Test Beam Results: Data

Radioactive Source	410	16339790
LED Pulser	125	183500
Pedestal	122	594400
Unknown	197	6648177
ECAL Calib (e)	394	6565934
HCAL Histograms	411	16367520
.OR.	3131	101830601

Run Type	Runs	Events
Electron/Positron	783	26467000
Muon	264	10470000
Pion	958	35156200

Data Stream	Runs	Events
HCAL Data	2434	79360547
ECAL Data	2408	78962534
Wire Chamber Data	2494	84217481
Phase Data	2497	84218081
HCAL Histograms	411	16367520

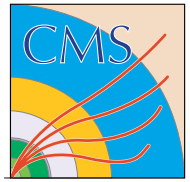
Runs: 3131

Spills: 53991

Events: 101830601

Run Statistics as of Wed Sep 18 21:00:02 2002

μ^- 225GeV
e^- 100, 20,30,50GeV
π^- 300, 20,30,50GeV



Data and Software

Data Files

- ROOT format
- All files (~300GB) are in the tape robots at CERN and Fermilab.

Software for Analyses

- HTBDAQ_data
  - http://flywheel.princeton.edu/~jmmans/HTBDAQ_data/
    - Provides data access methods to DAQ root files
- Simple C++/root scripts to analyze data.
  - e.g. wire source analysis
- H2Reco
  - http://home.fnal.gov/~jdamgov/h2reco/
    - Reads DAQ root file using HTBDAQ_data.
    - Construct higher level objects, e.g. 1x1, 3x3, 5x5 ECAL or HCAL clusters in addition to raw ECAL and HCAL data, etc.
    - Writes output root files
  - V11 was used for quick data validation during September runs.
  - V12 includes calibration by the wire source data and “phase” calculated with energy weighted time slice.
    - Most of runs have been processed through V12 at Fermilab..

System Problems

In consistent QIE calibration constants.

- Calibration constants from Fermilab did not match to actual QIE response at TB.

Multi TeV events

- Corruption of QIE data for a few events to >500 events.

CapID rotation error.

- CapID should rotate 0-1-2-3-0-1-2…, but not.

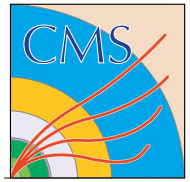
Drift of pedestals in beam and source modes.

- Pedestal split for different CapID.

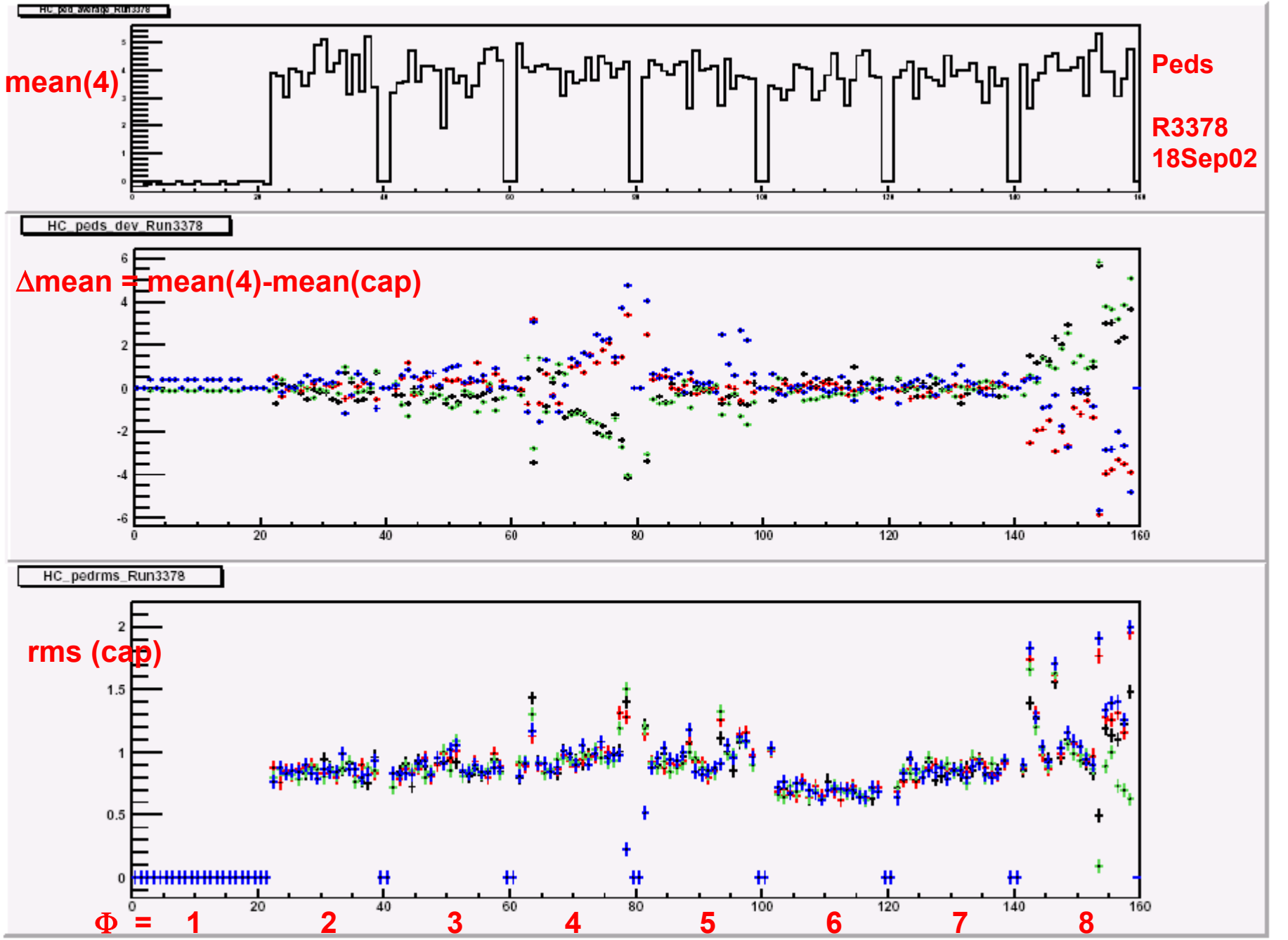
HTR event number increment error.

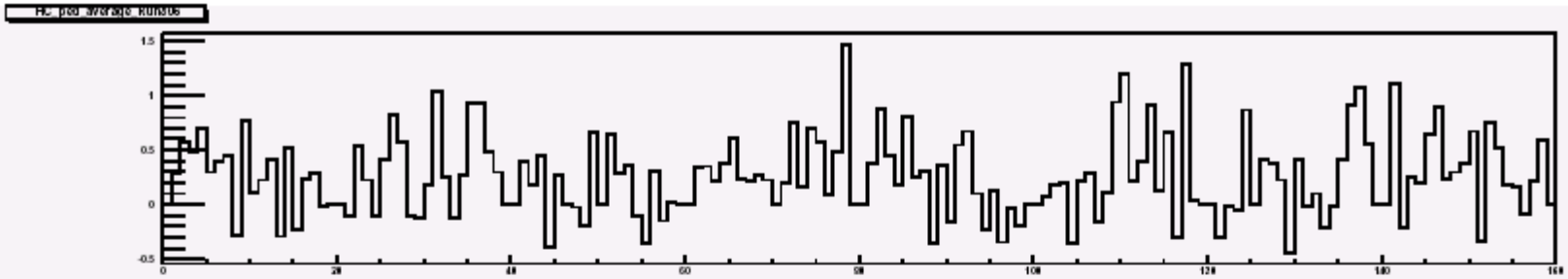
Jitter in TDC measurement

- for Phase and Wire chamber. – false alarm???



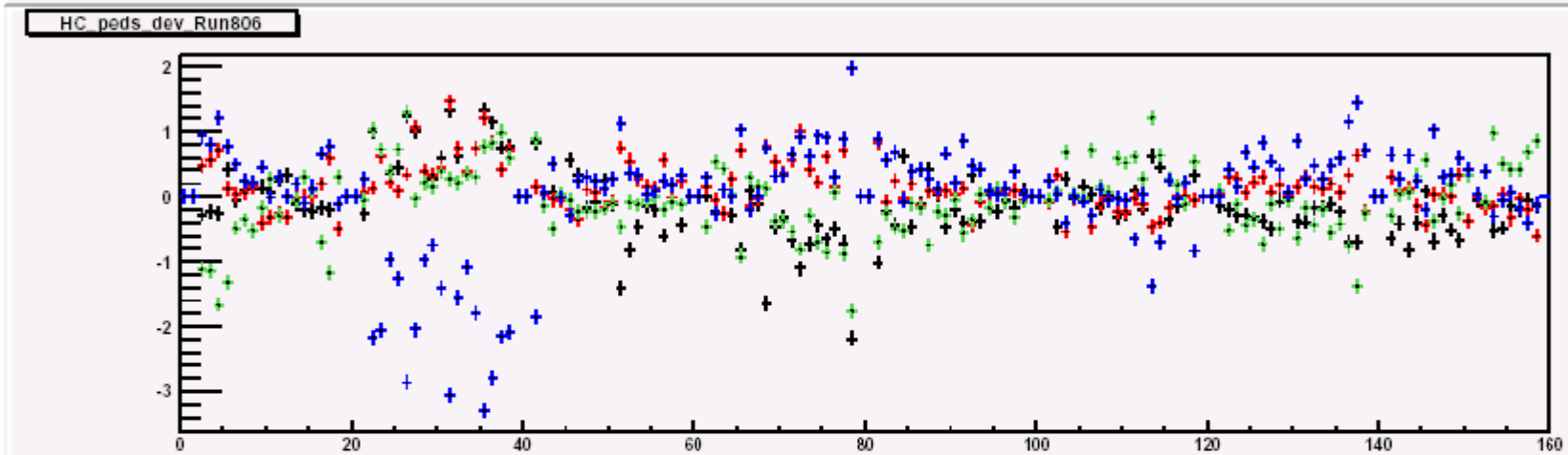
Pedestals

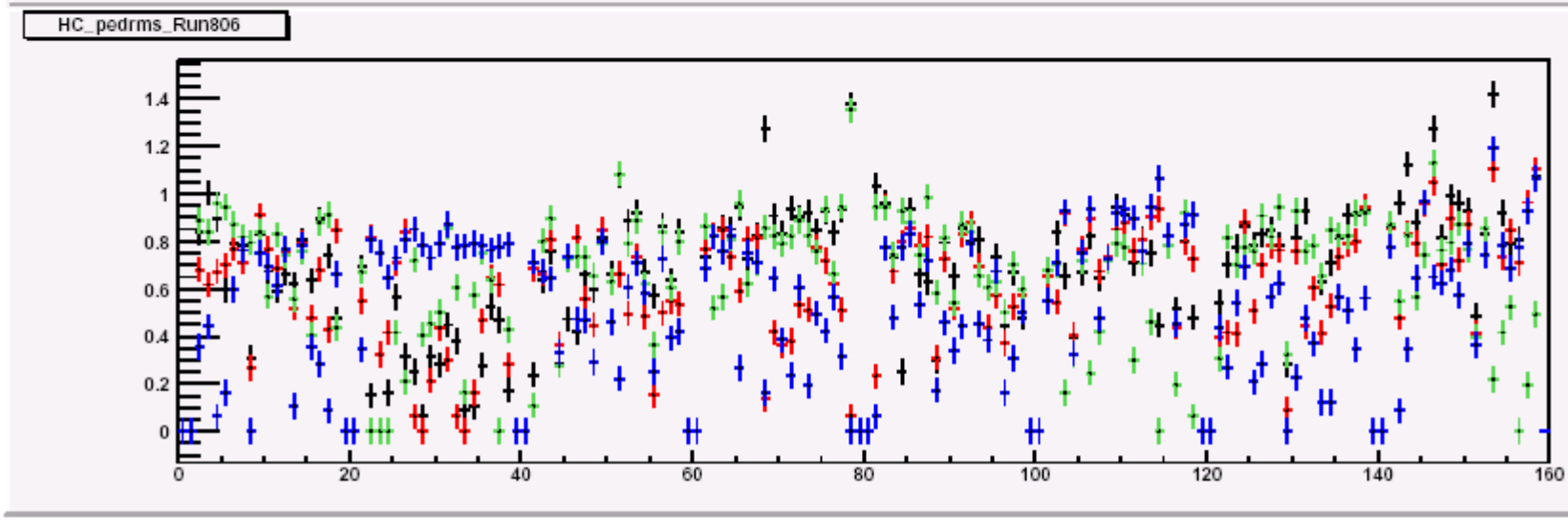

mean(4)
Peds
R3378
18Sep02
HC_peds_dev_Run3378
Δmean = mean(4)-mean(cap)
HC_pedrms_Run3378
rms (cap)
Φ = 1 2 3 4 5 6 7 8



Peds

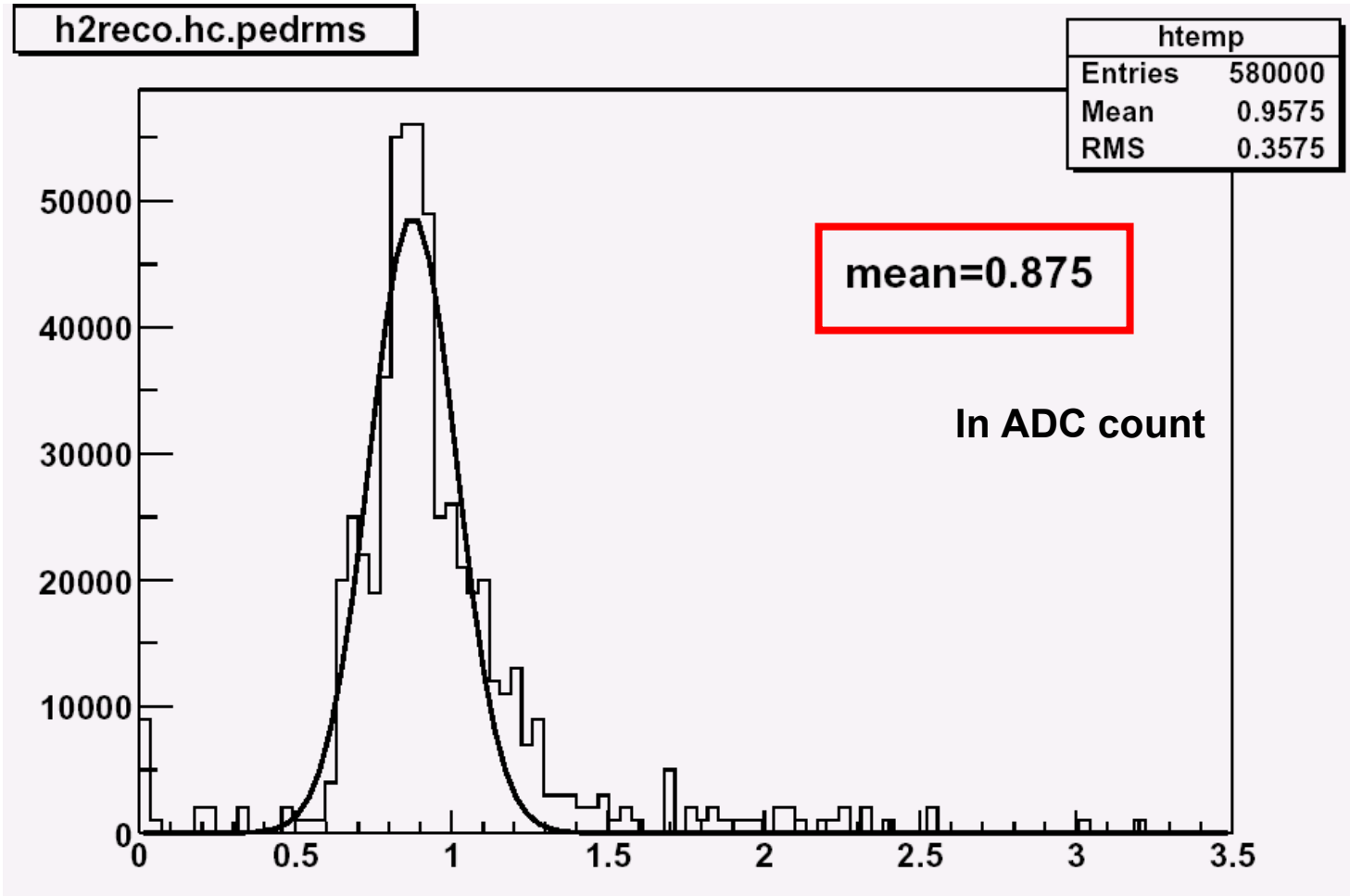
R806
9Aug02





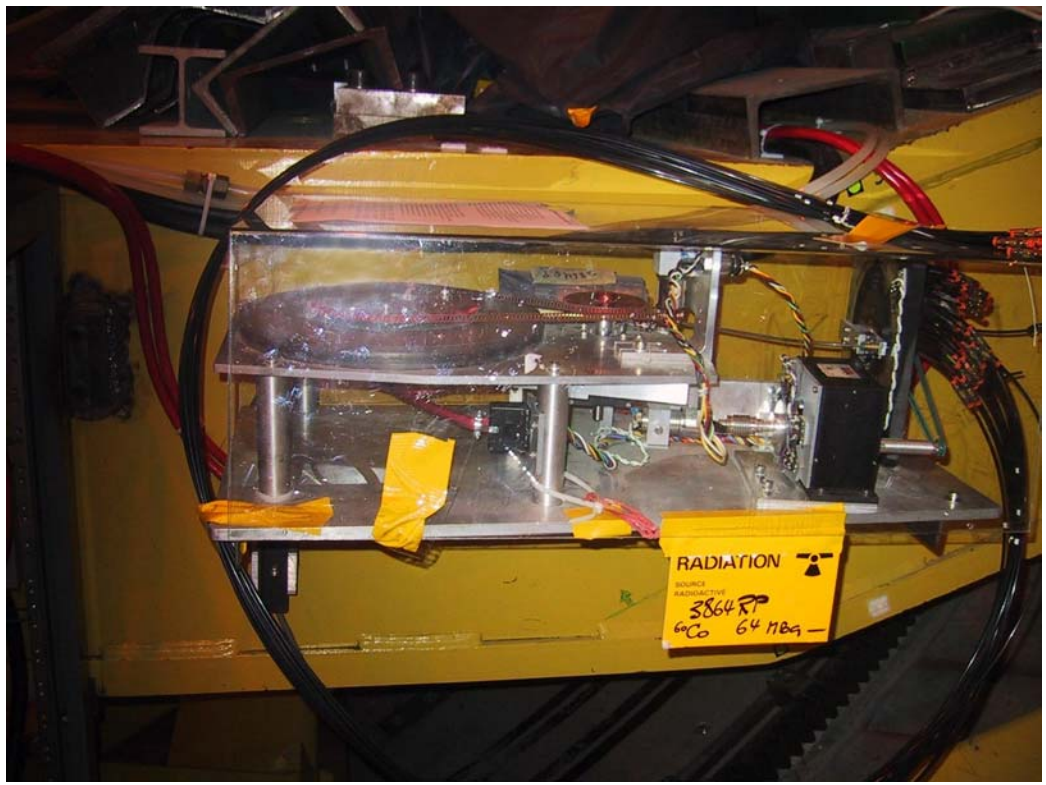
Noise Level

Pedestal RMS distribution

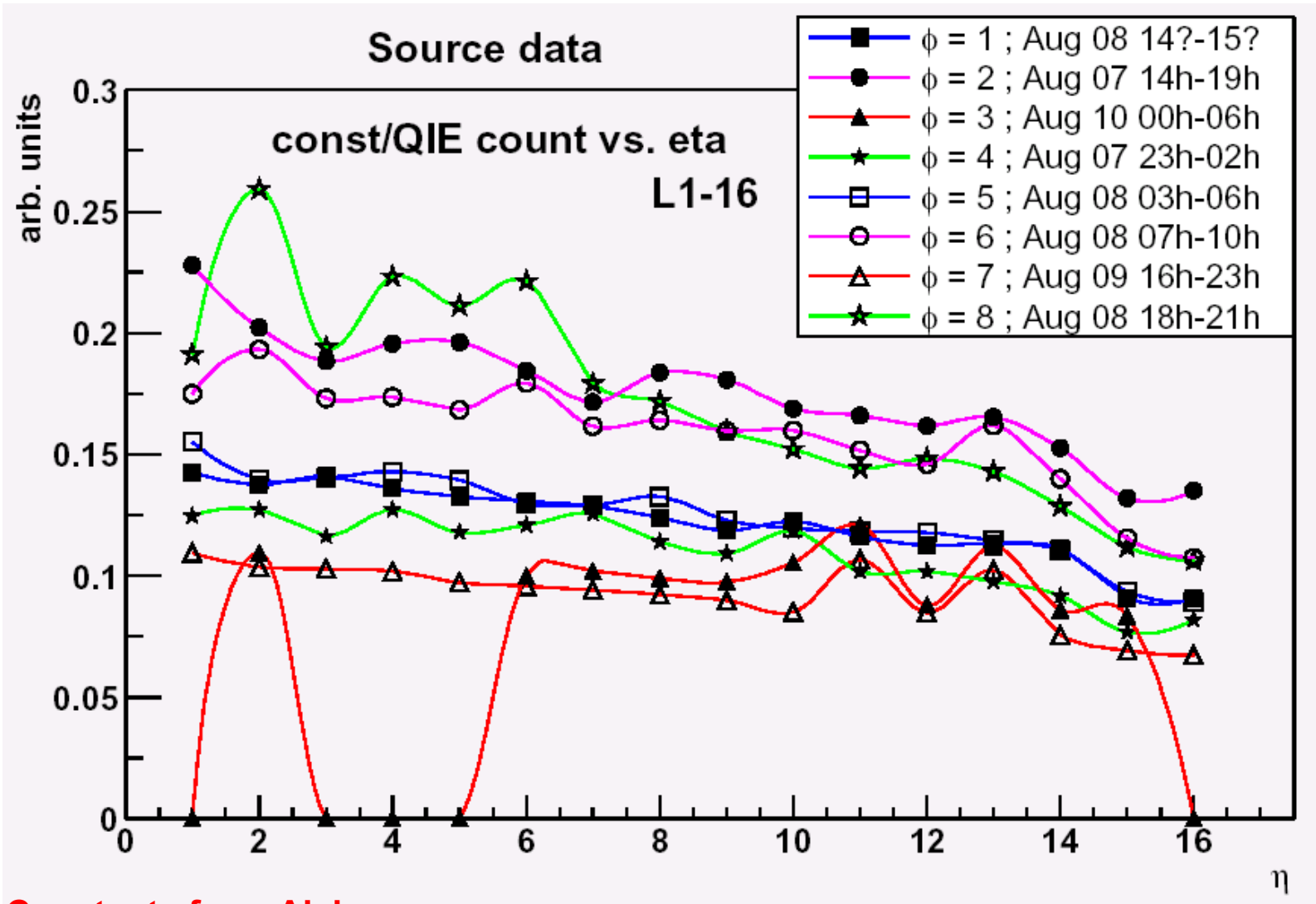


Source scan uses QIE at 25 nsec to sum up to a D.C. current. Signal to noise is good (3 mCu). Assignment of calibration constant to tile is simple.

Wire Source Scan

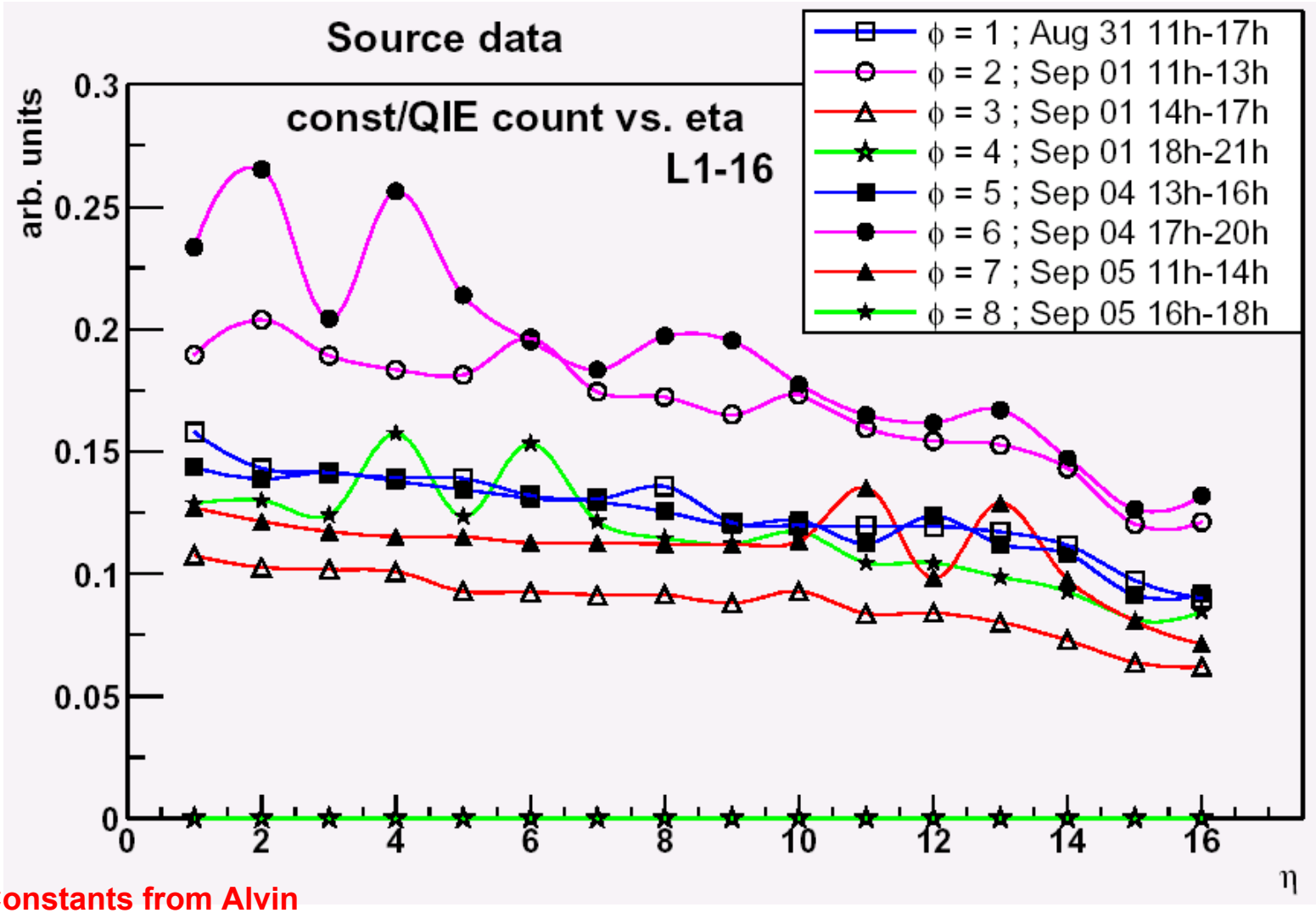


Wire Source (Aug. run)



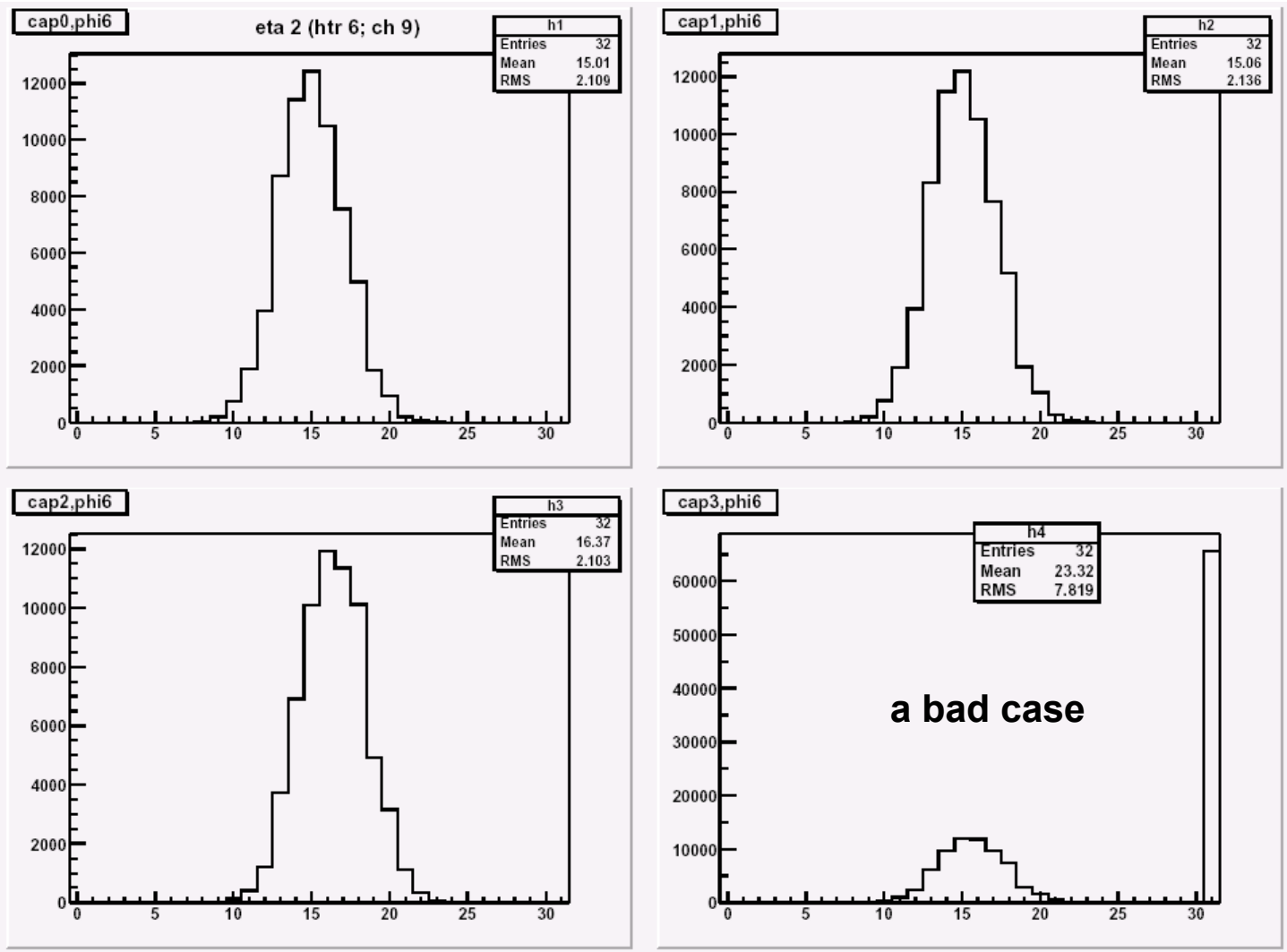
Constants from Alvin

Wire Source (Sep. run)

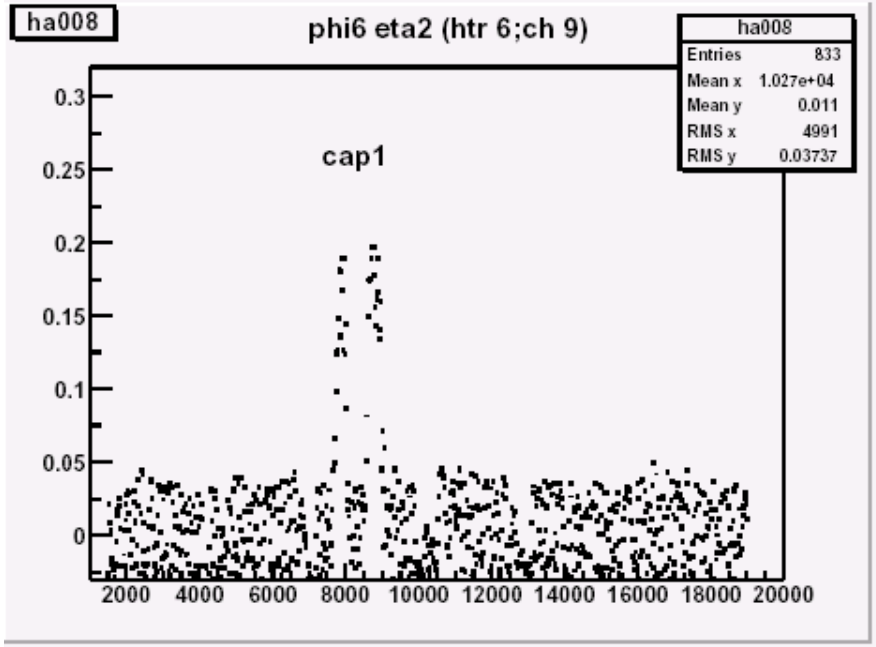


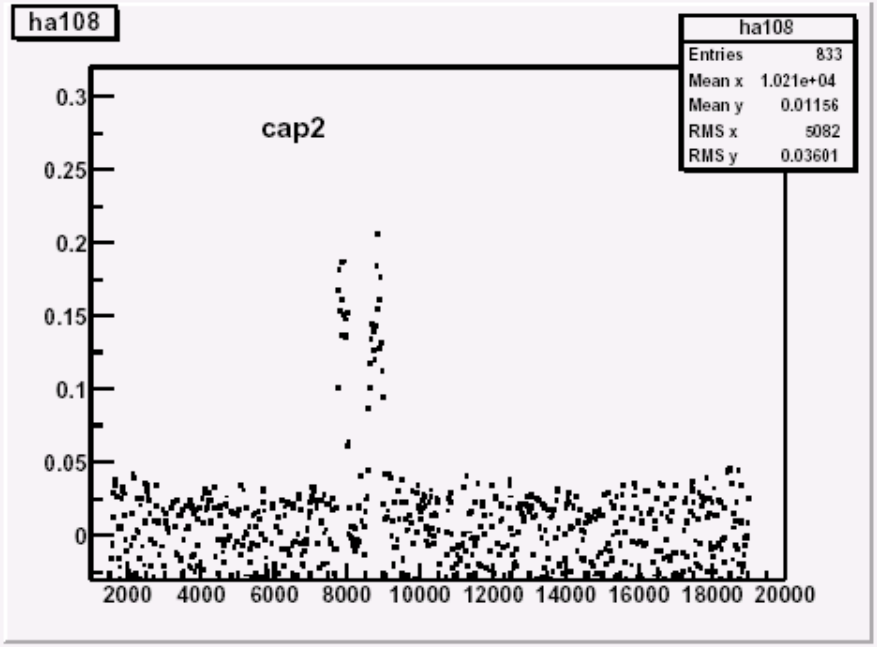
Constants from Alvin

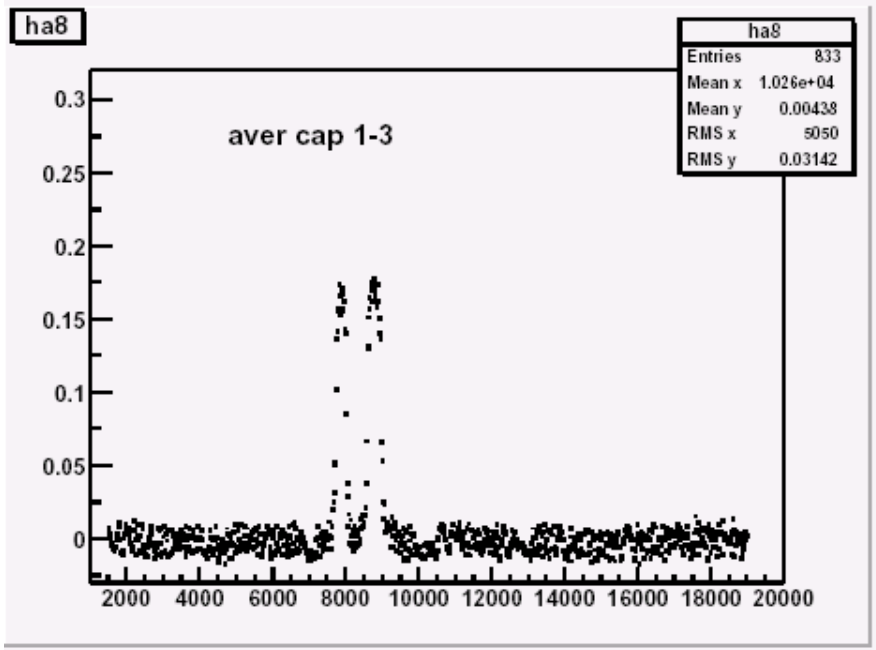
Source Histograms by HTR

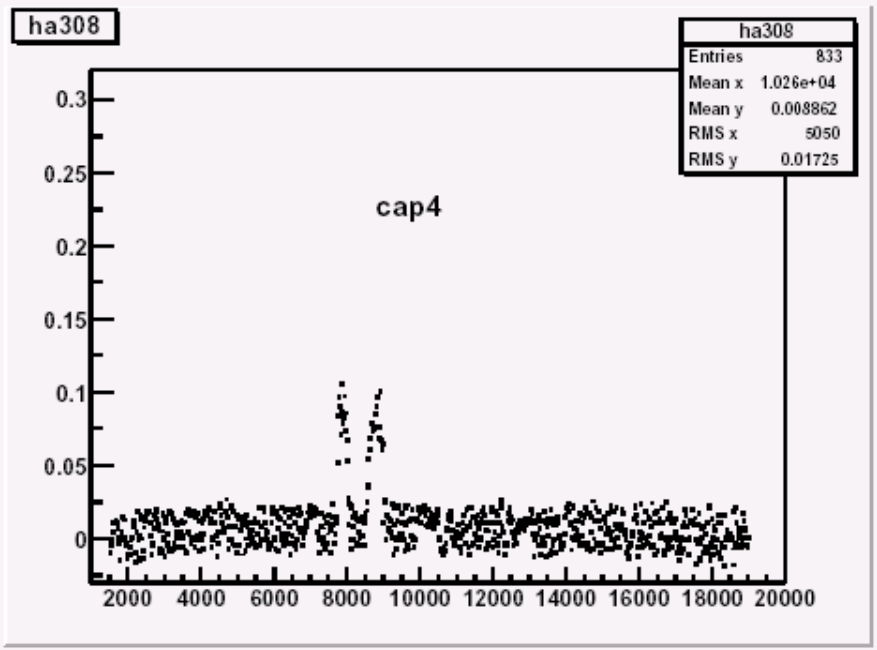


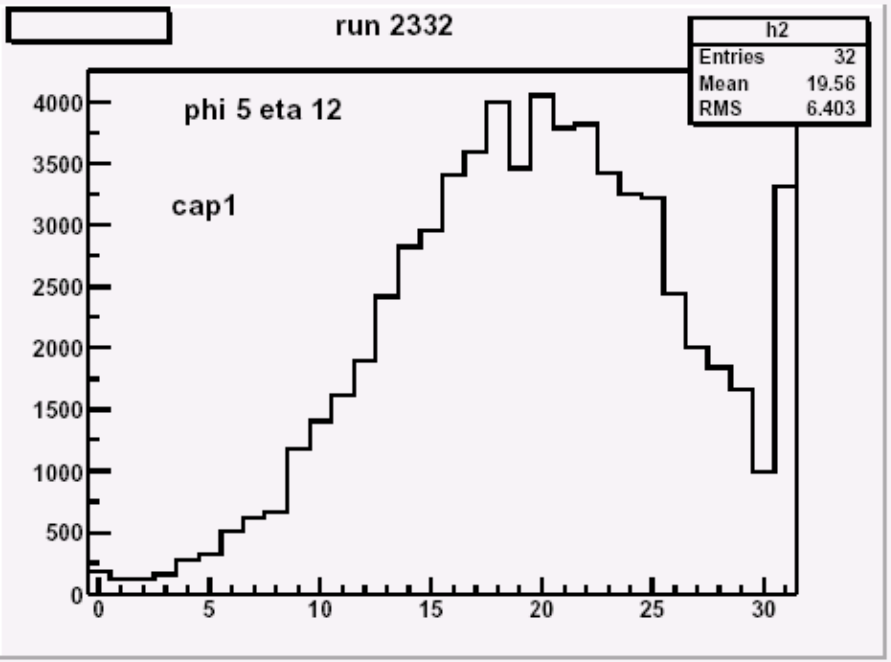
ADC count (in 3x mode)

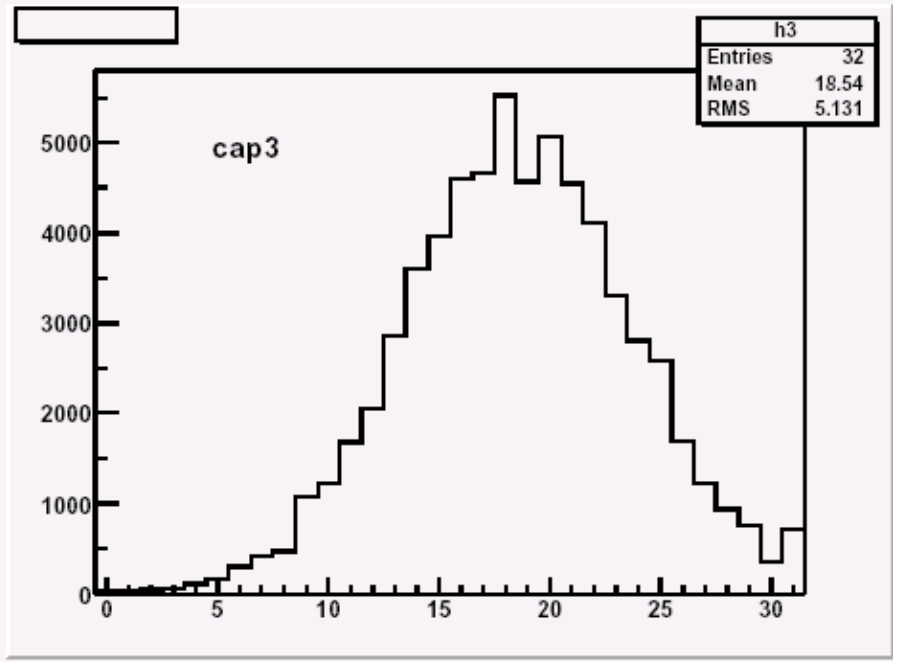

ha008
phi6 eta2 (htr 6;ch 9)
cap1
ha008
Entries 833
Mean x 1.027e+04
Mean y 0.011
RMS x 4991
RMS y 0.03737

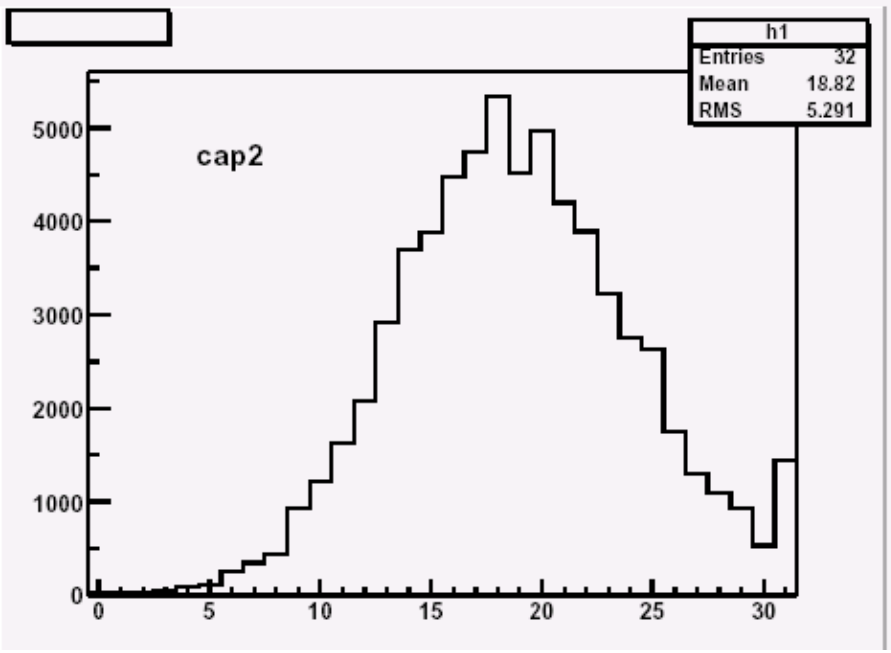

ha108
cap2
ha108
Entries 833
Mean x 1.021e+04
Mean y 0.01156
RMS x 5082
RMS y 0.03601

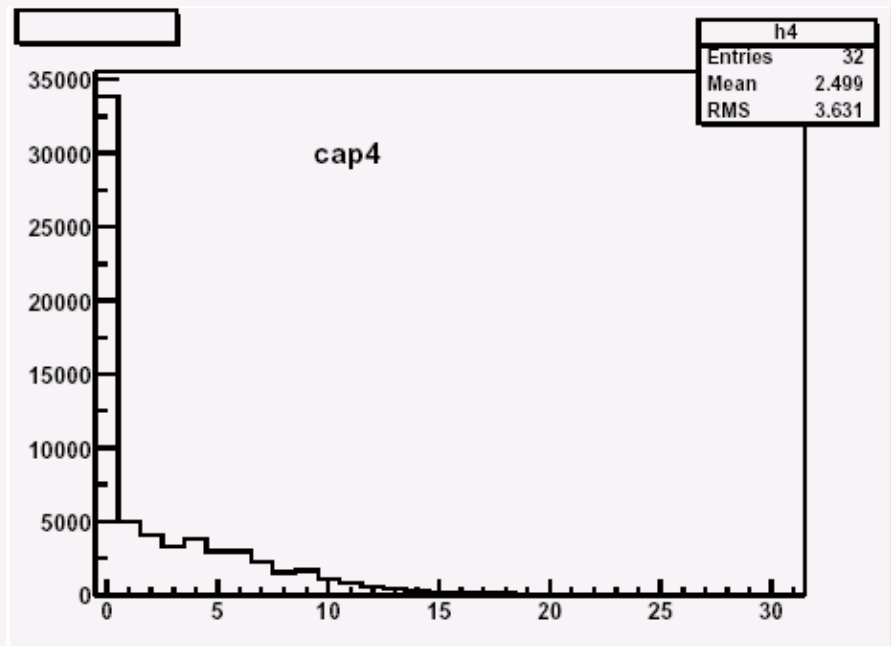

ha8
aver cap 1-3
ha8
Entries 833
Mean x 1.026e+04
Mean y 0.00438
RMS x 5050
RMS y 0.03142


ha308
cap4
ha308
Entries 833
Mean x 1.026e+04
Mean y 0.008862
RMS x 5050
RMS y 0.01725


run 2332
h2
Entries 32
Mean 19.56
RMS 6.403
phi 5 eta 12
cap1

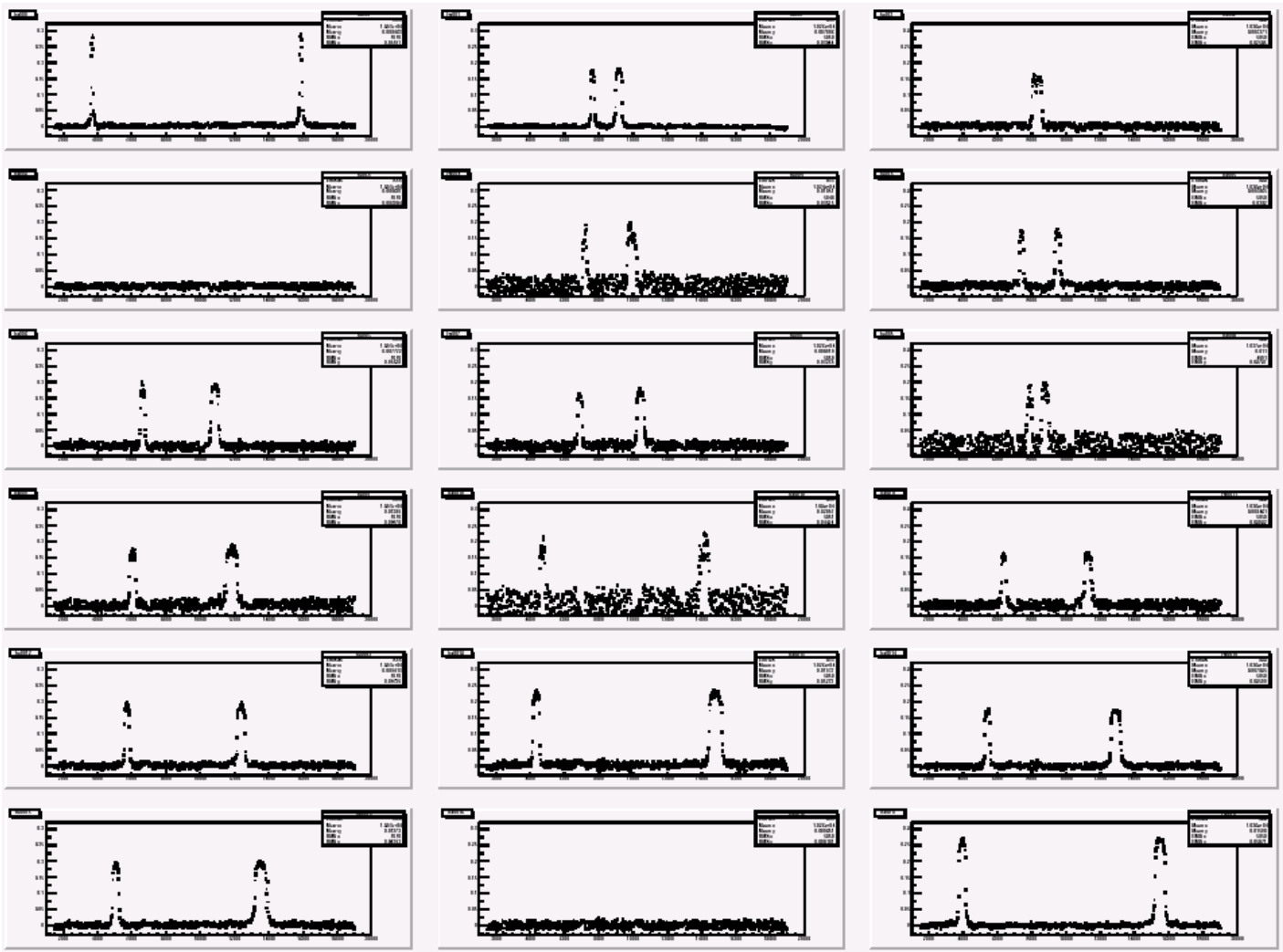

h3
Entries 32
Mean 18.54
RMS 5.131
cap3


h1
Entries 32
Mean 18.82
RMS 5.291
cap2


h4
Entries 32
Mean 2.499
RMS 3.631
cap4

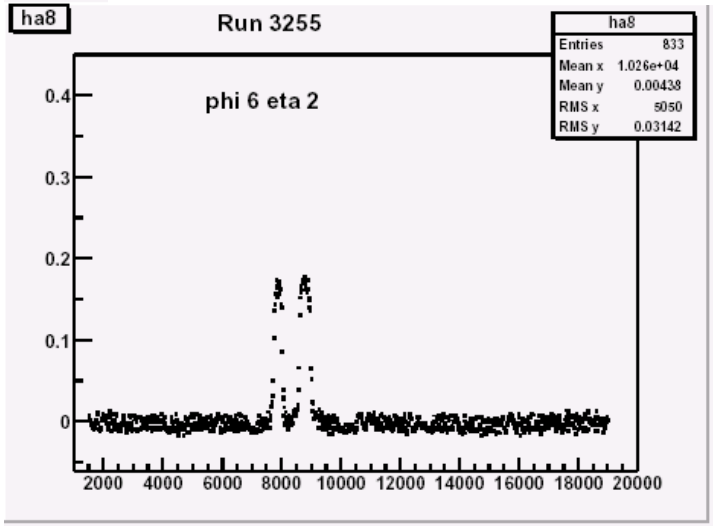
Wire Source

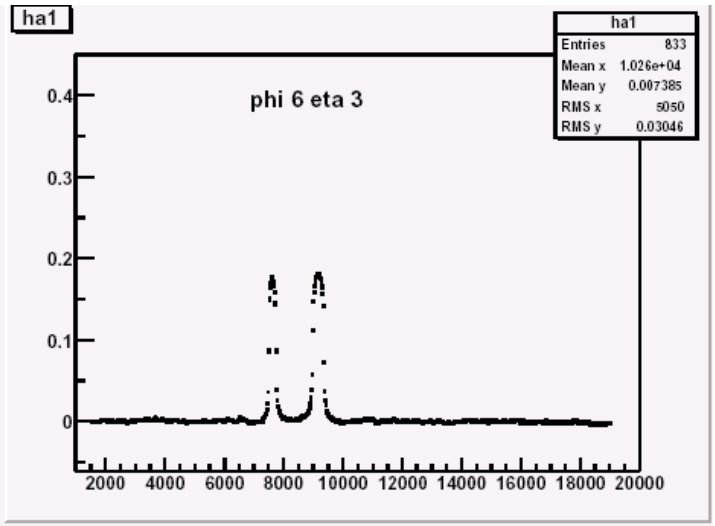
each point – guassian fit to histograms

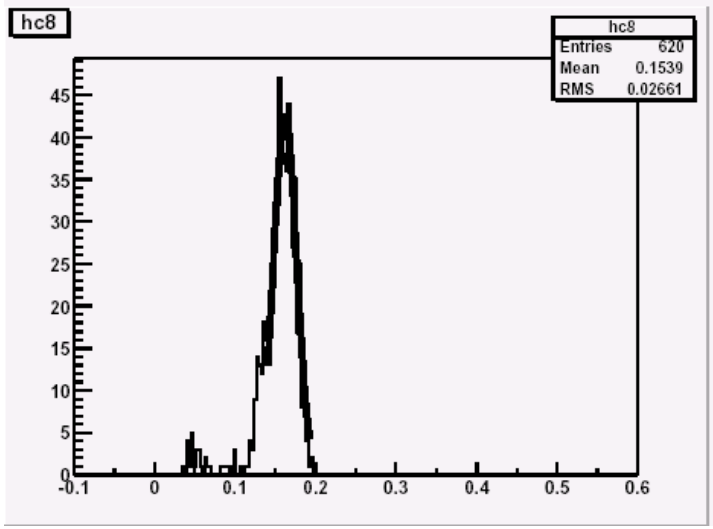


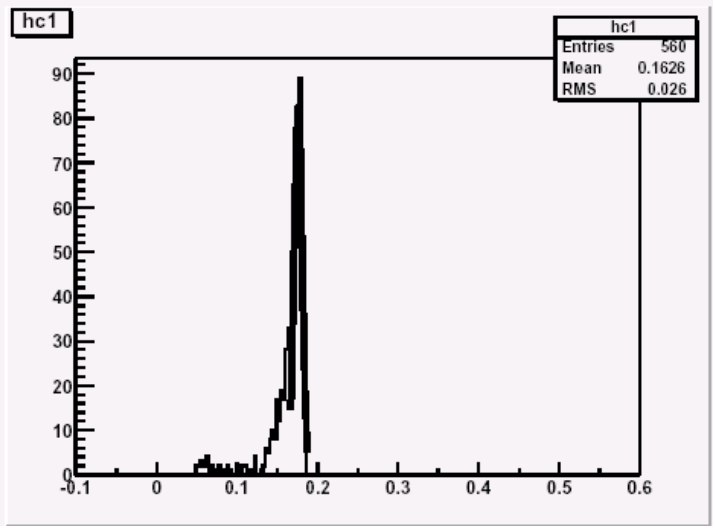
Some channels are noisier than others.

Gaussian Fit to y projection



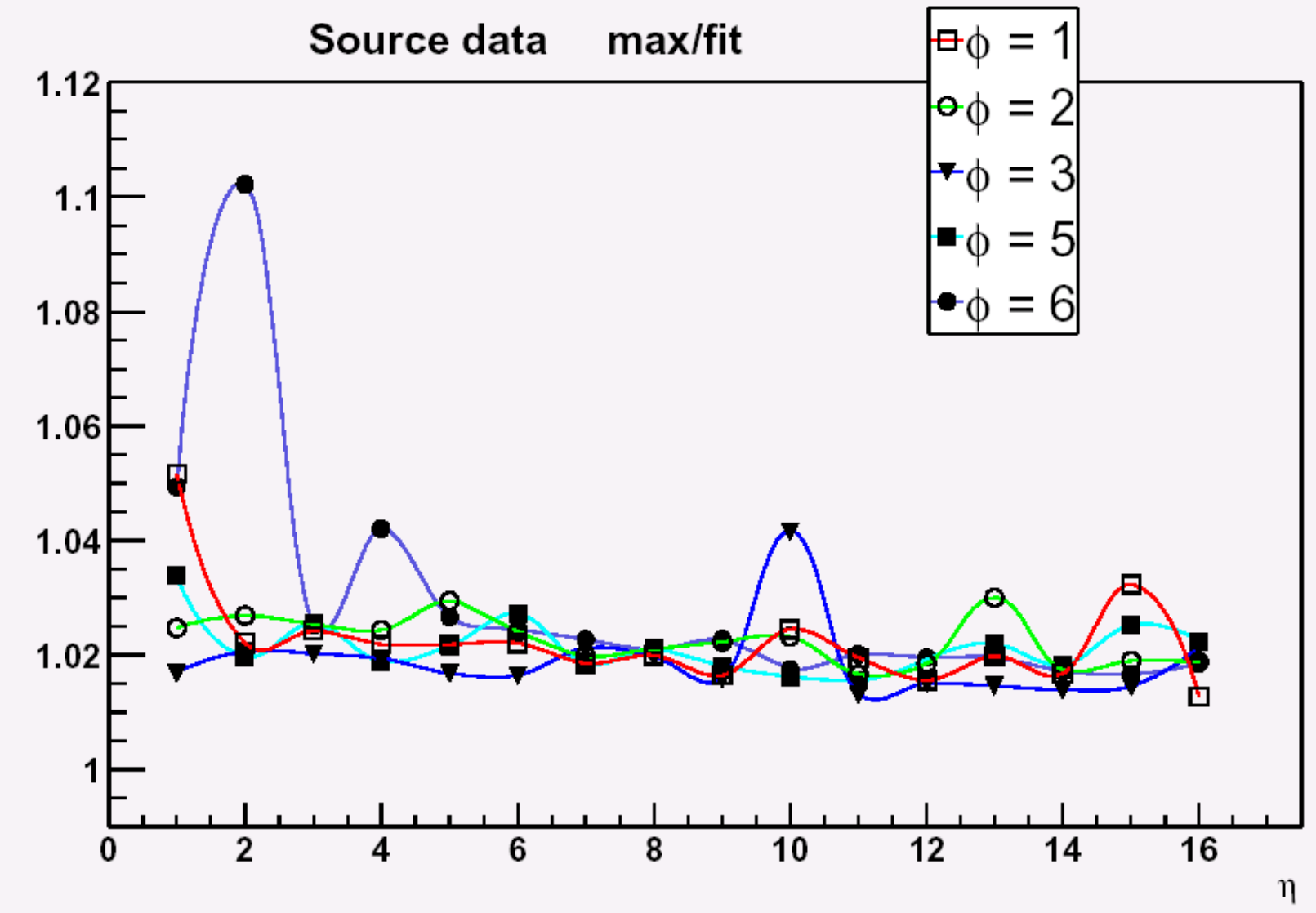


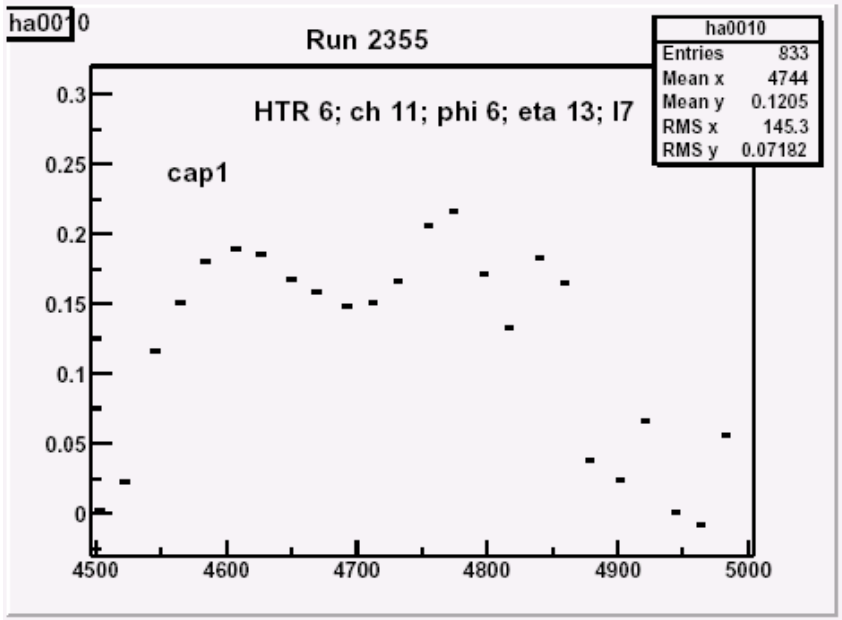


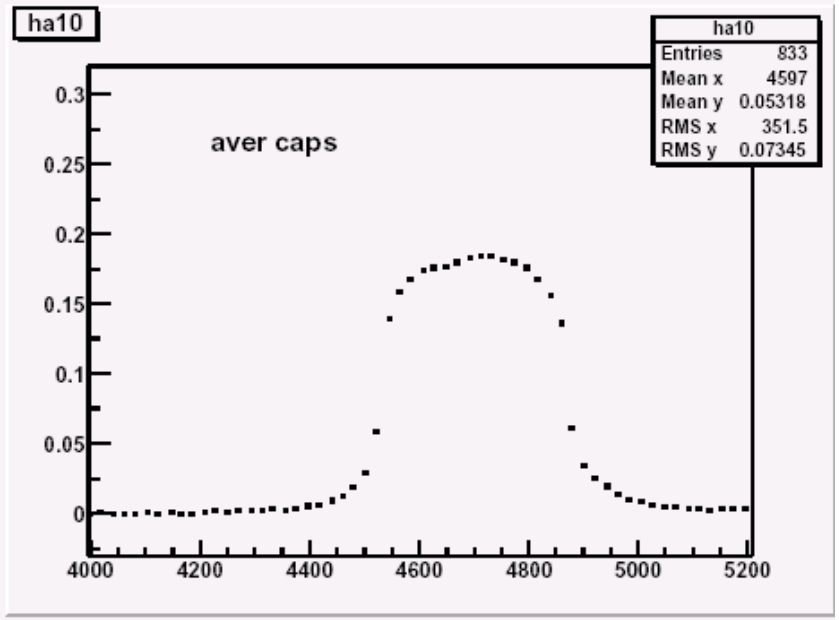


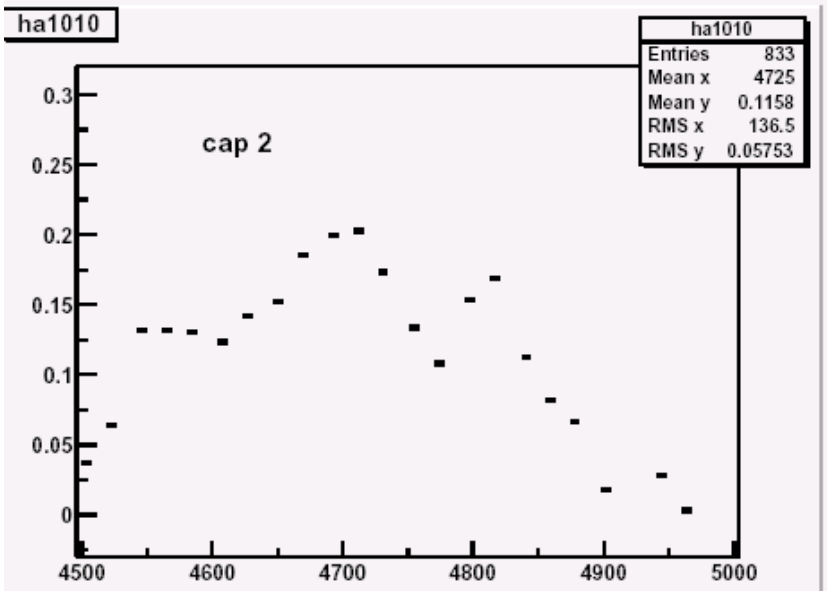
Fitted values are less sensitive to pedestal width.

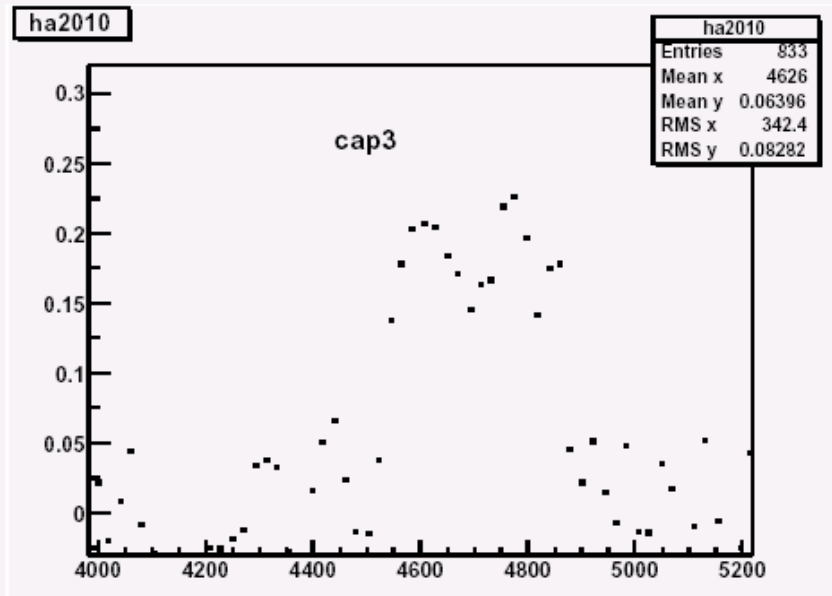
Max vs Fit


Source data max/fit
ϕ = 1
ϕ = 2
ϕ = 3
ϕ = 5
ϕ = 6
1.12
1.1
1.08
1.06
1.04
1.02
1
0
2
4
6
8
10
12
14
16
η

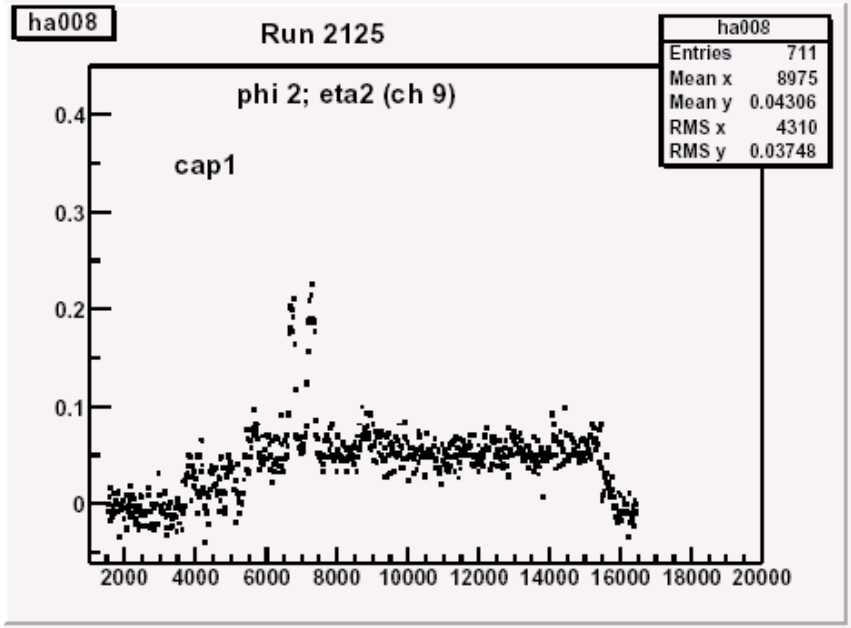


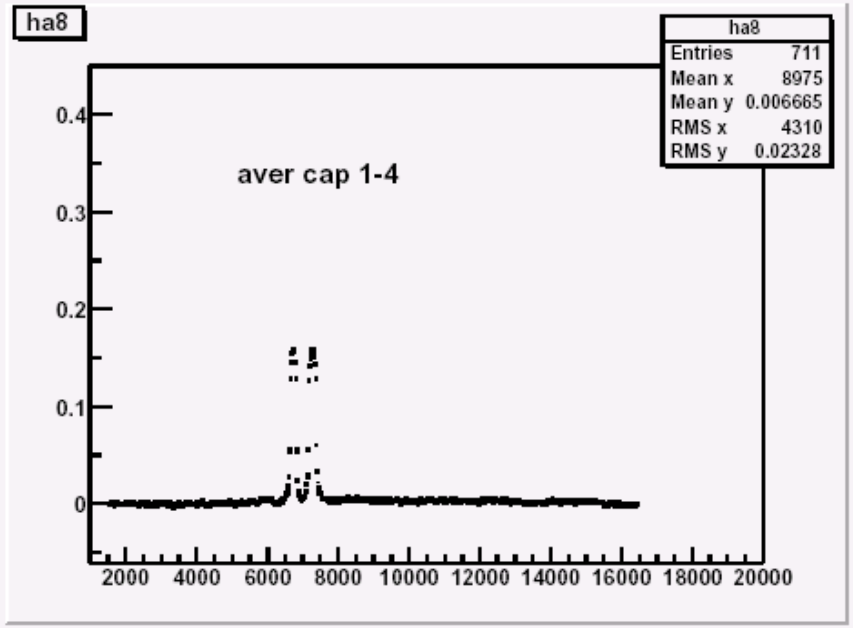


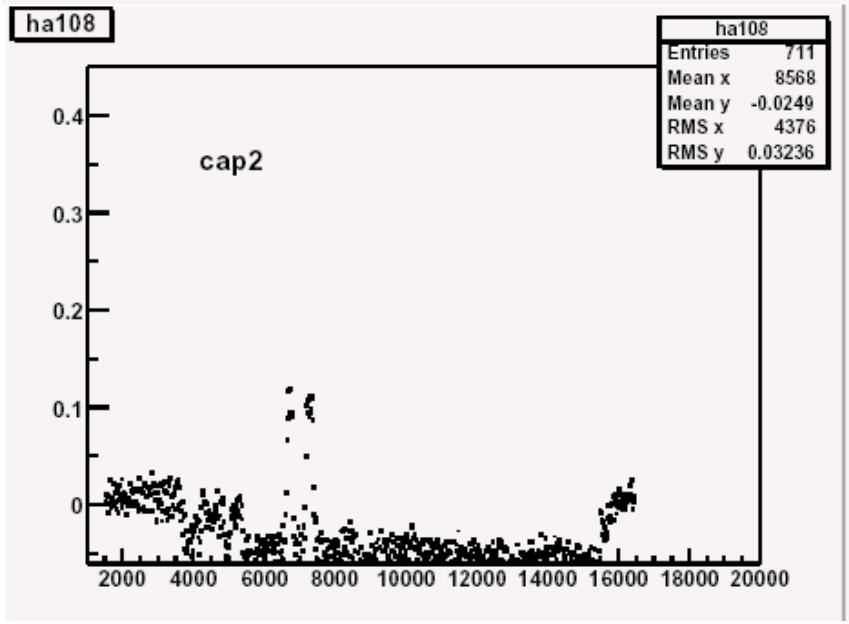


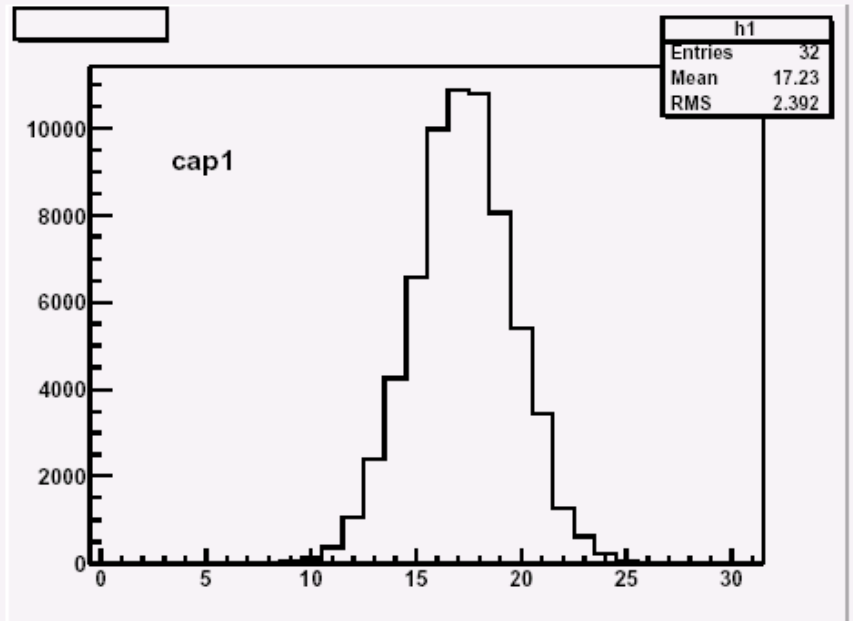


Calibration constants for individual CapID are useless.

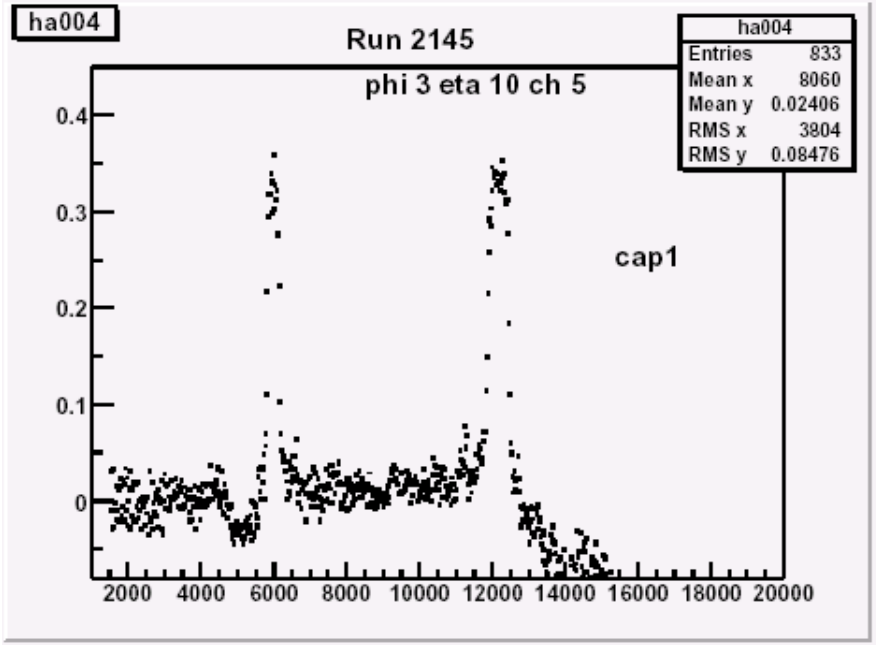


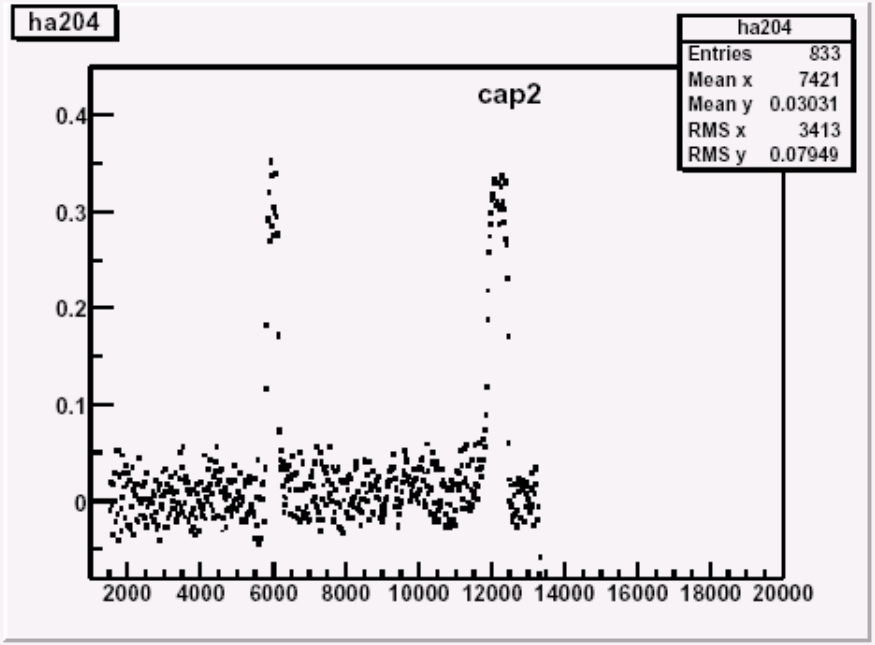


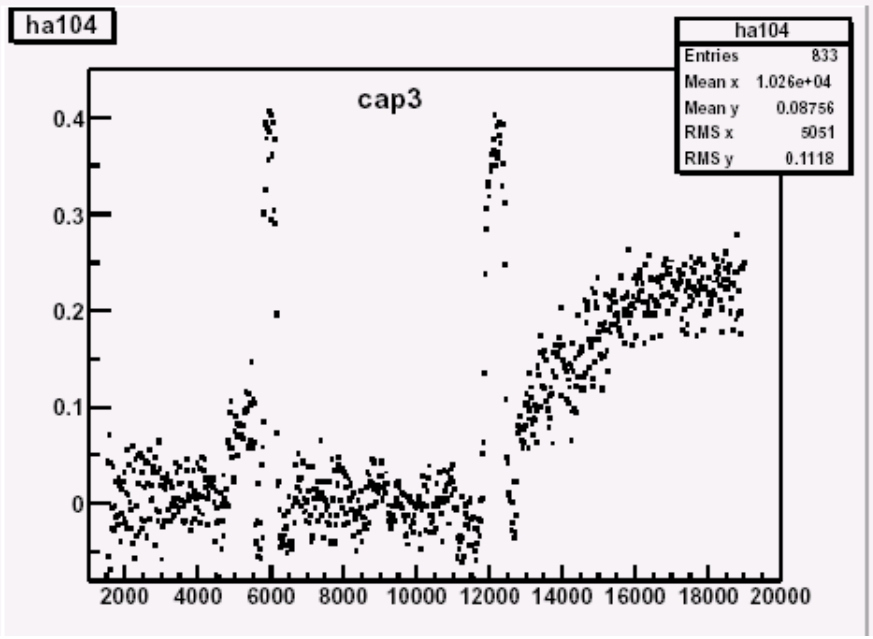


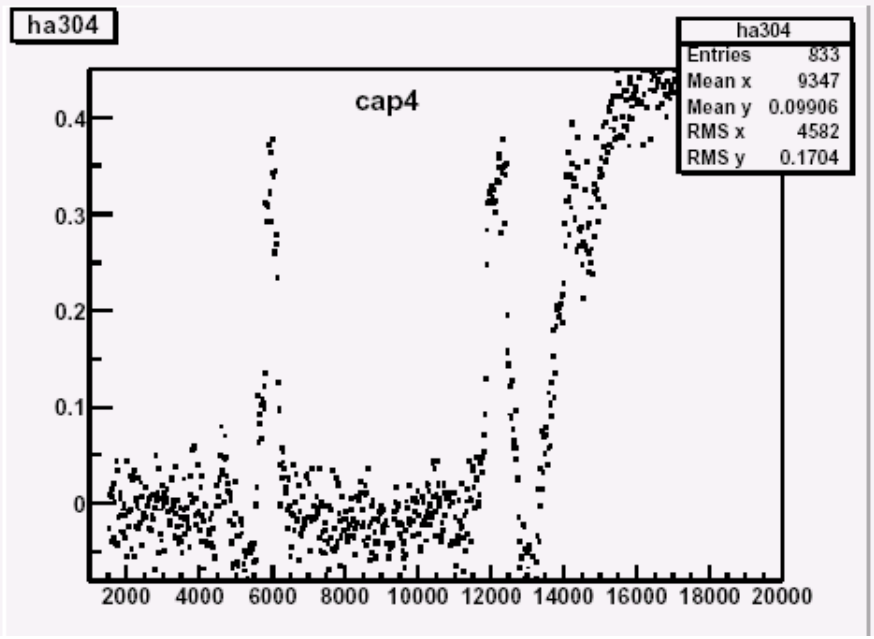


Peds drifted during the run.

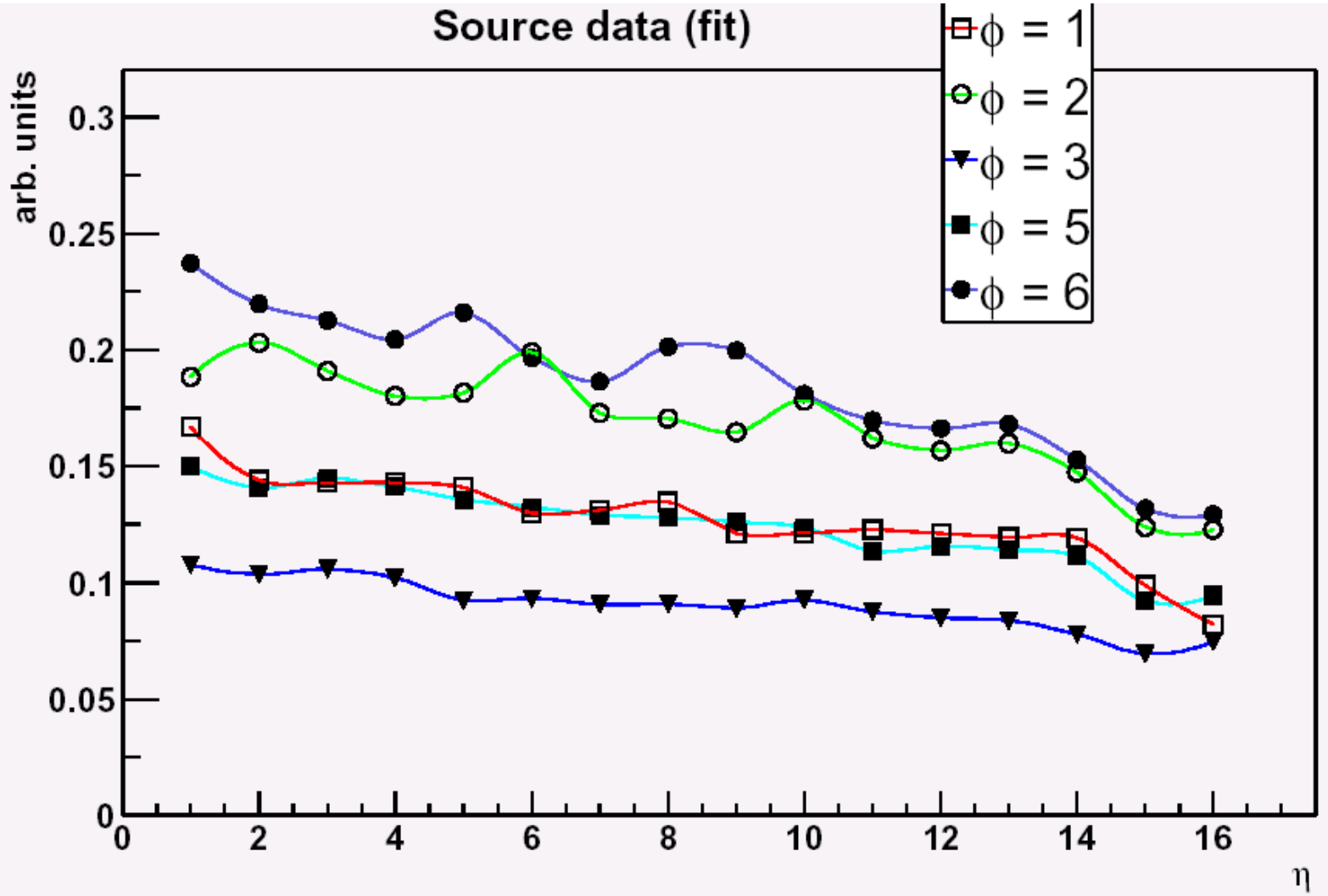

ha004
Run 2145
phi 3 eta 10 ch 5
cap1
ha004
Entries 833
Mean x 8060
Mean y 0.02406
RMS x 3804
RMS y 0.08476


ha204
cap2
ha204
Entries 833
Mean x 7421
Mean y 0.03031
RMS x 3413
RMS y 0.07949

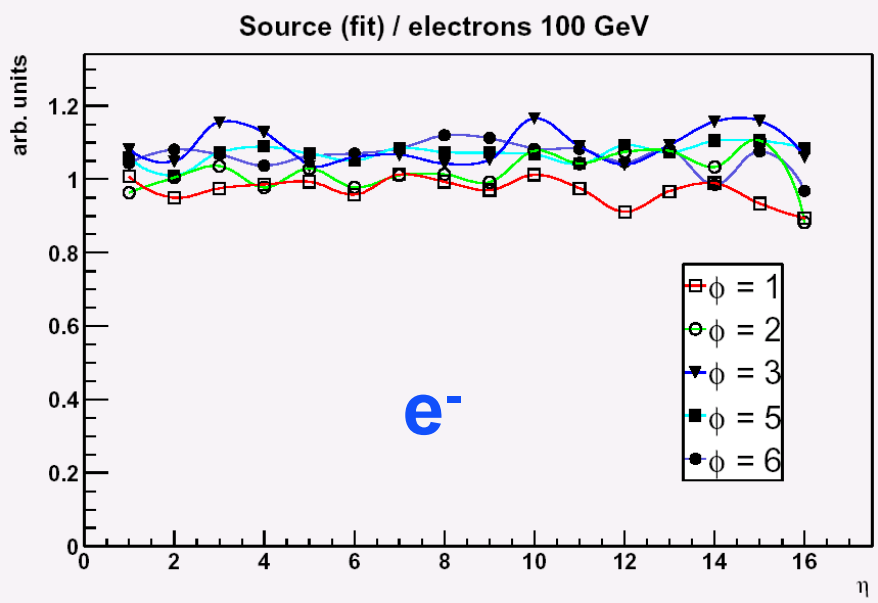

ha104
cap3
ha104
Entries 833
Mean x 1.026e+04
Mean y 0.08756
RMS x 5051
RMS y 0.1118

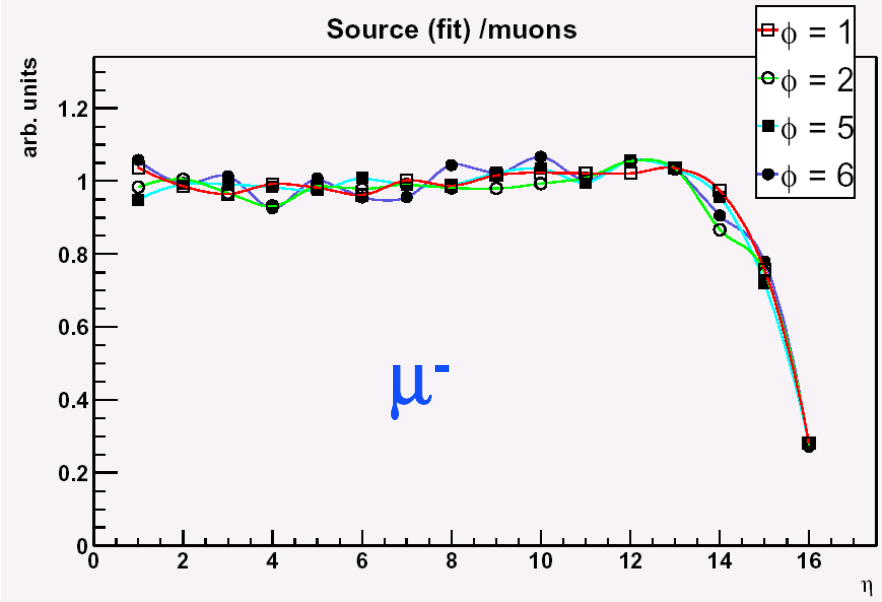

ha304
cap4
ha304
Entries 833
Mean x 9347
Mean y 0.09906
RMS x 4582
RMS y 0.1704

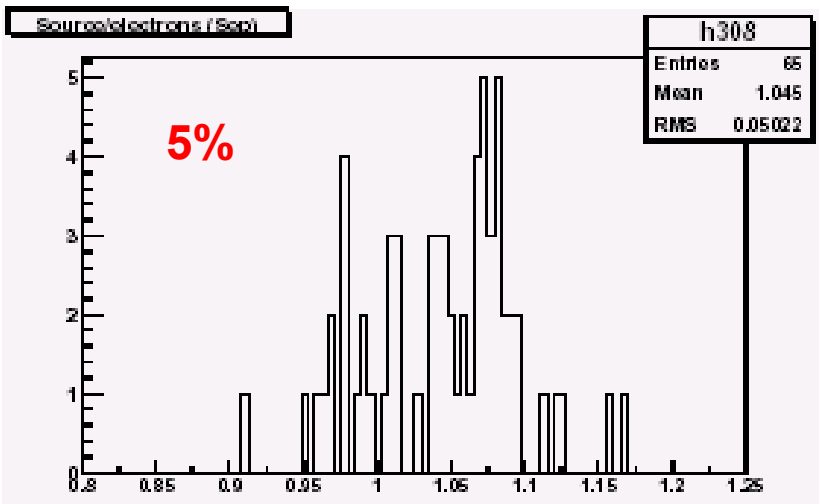
Wire Soburce Data

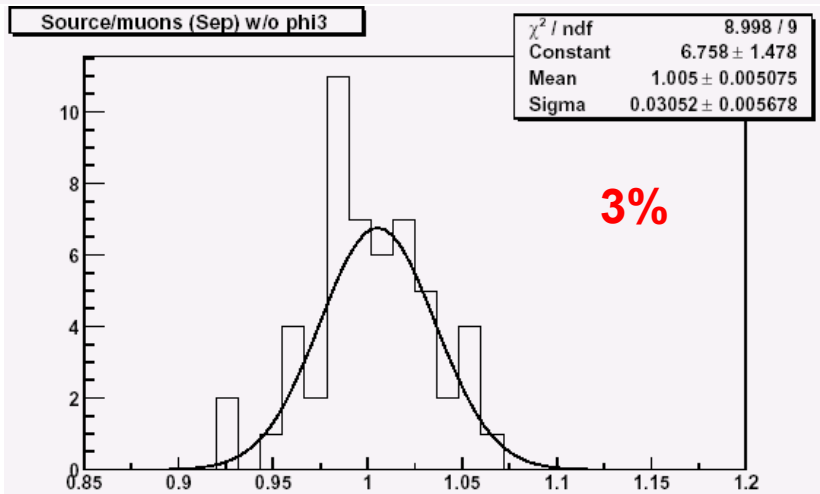


Source vs Beam Data

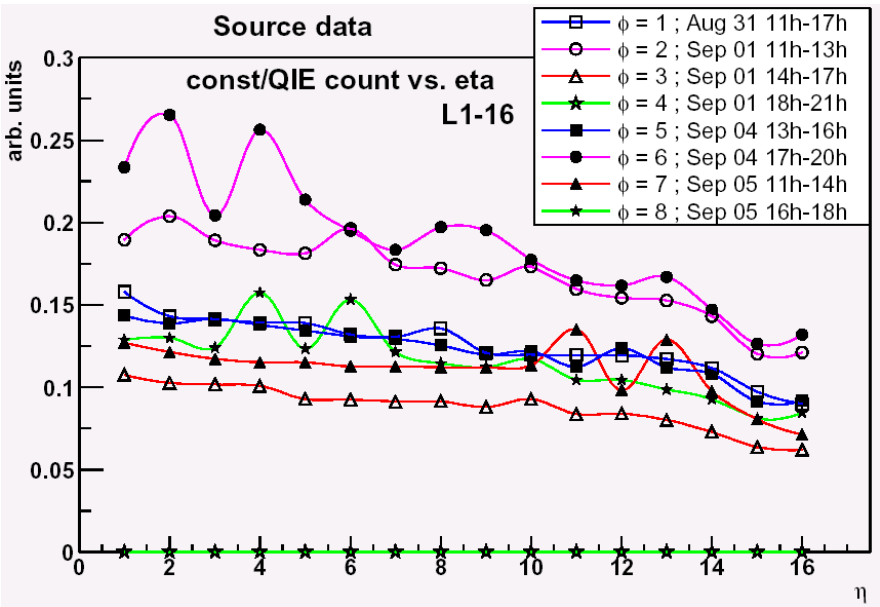


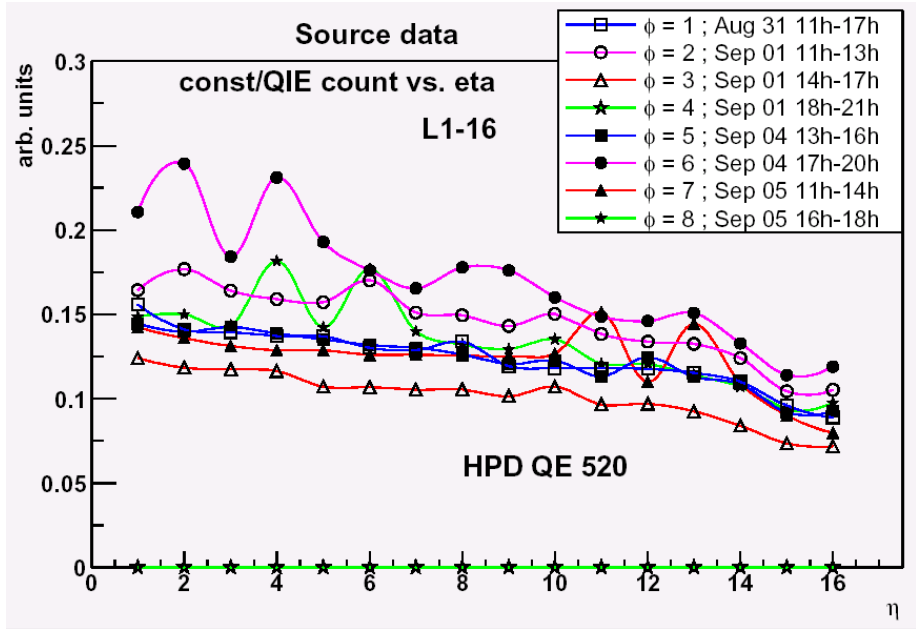






HPD QE Correction





HPD QE does not explain variation in phi fully.

ADC → GeV

7 bits ADC

Inverting Input Scale (HPD Inputs)

Normal Mode			
Range (Exponent)	Input Charge	FADC Codes	Gain (q/Lsb)
0	-1 fC --- 14 fC	0---14	1 fC/bin
0	14 fC --- 28 fC	15---21	2 fC/bin
0	28 fC --- 40 fC	22---25	3 fC/bin
0	40 fC --- 52 fC	26---28	4 fC/bin
0	52 fC --- 67 fC	29---31	5 fC/bin
1	57 fC --- 132 fC	0---14	5 fC/bin
1	132 fC --- 202 fC	15---21	10 fC/bin
1	202 fC --- 262 fC	22---25	15 fC/bin
1	262 fC --- 322 fC	26---28	20 fC/bin
1	322 fC --- 397 fC	29---31	25 fC/bin
2	347 fC --- 722 fC	0---14	25 fC/bin
2	722 fC --- 1072 fC	15---21	50 fC/bin
2	1072 fC --- 1372 fC	22---25	75 fC/bin
2	1372 fC --- 1672 fC	26---28	100 fC/bin
2	1672 fC --- 2047 fC	29---31	125 fC/bin
3	1797 fC --- 3672 fC	0---14	125 fC/bin
3	3672 fC --- 5422 fC	15---21	250 fC/bin
3	5422 fC --- 6922 fC	22---25	375 fC/bin
3	6922 fC --- 8422 fC	26---28	500 fC/bin
3	8422 fC --- 10297 fC	29---31	625 fC/bin
Calibration Mode			
Forced 0	-2.333 fC ---- 10 fC	0---31	1/3 fC/Bin

ADC Codes

00 - 31 **(0 - 20GeV)**

32 - 63 **(17 - 119GeV)**

64 - 95 **(104 - 614GeV)**

96 - 127 **(539- 3089GeV)**

Dynamic Range

Original Requirement:

Jets: 15-20GeV for top reconstruction/rejection
>3TeV for compositness & QCD

Readout: Et Threshold 500MeV
Max. E = 3TeV
Noise < 200MeV/time slice (<0.66 LSB)

QIE(ADC): 7 bits (128 integer codes in non-linear scale)
1-10000 counts equivalent in linear scale.
300MeV LSB
3TeV at the max scale

Resolution
Energy offset
Occupancy

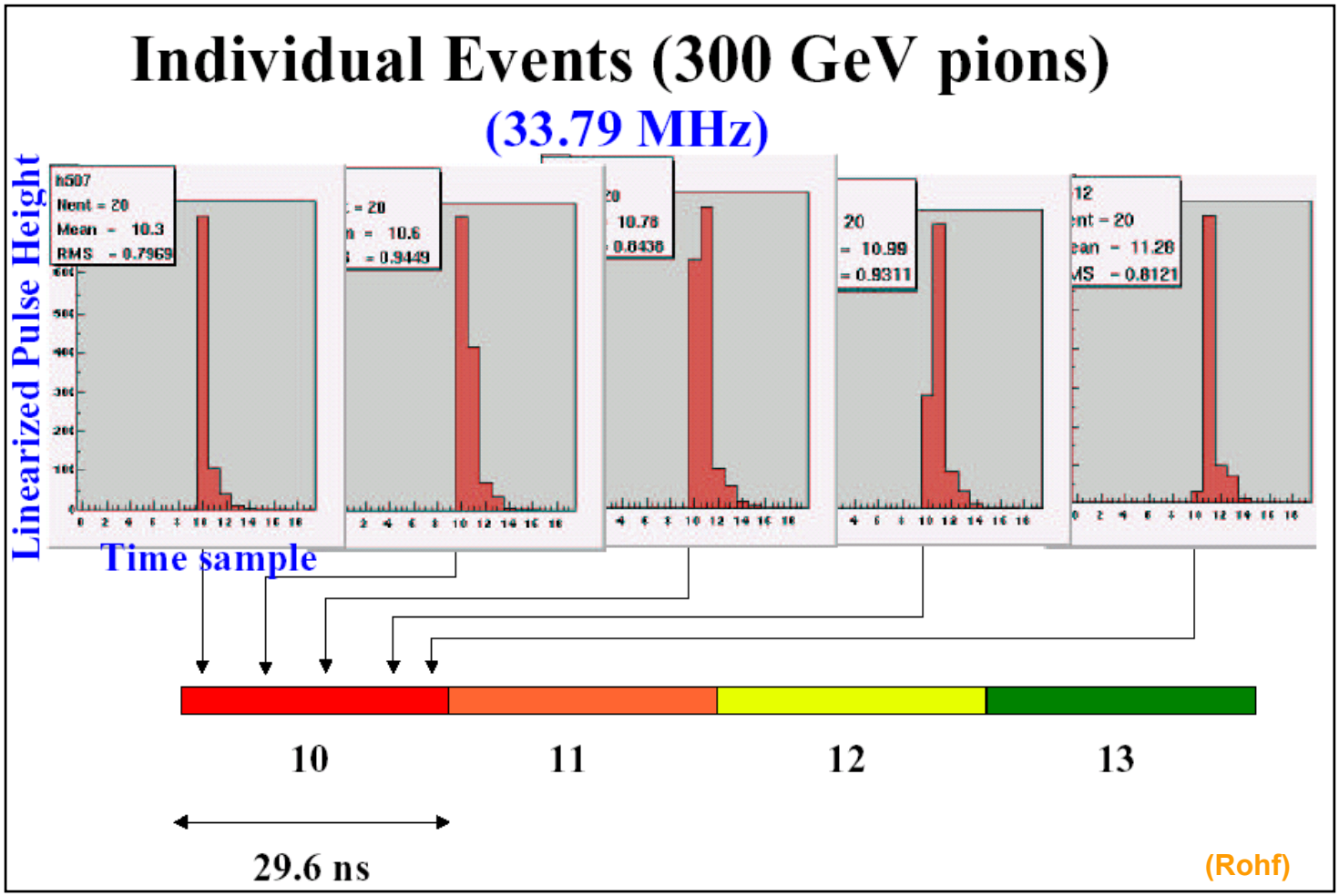
0.9 LSB (TB2002)

Pedestal: Higher statistics for better mean value
→ before/after physics runs.
→ during abort gaps.

Energy extraction:
→ Optical sum of layer 0 signal with others.
→ 1 or 2 time slices for signal extraction.

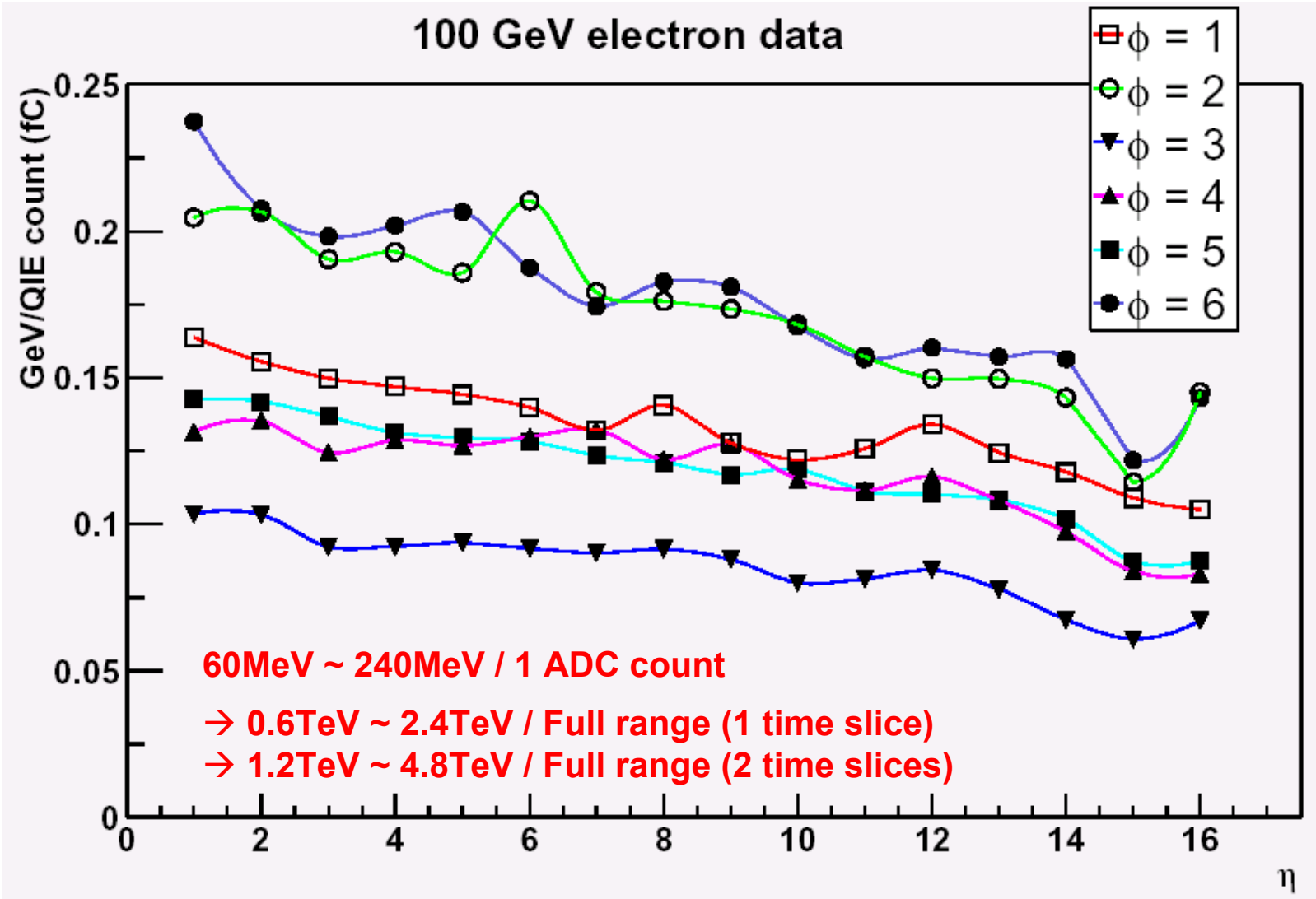
Signal in Time Slices

No synchronization between beam arrival time and QIE clock at TB.



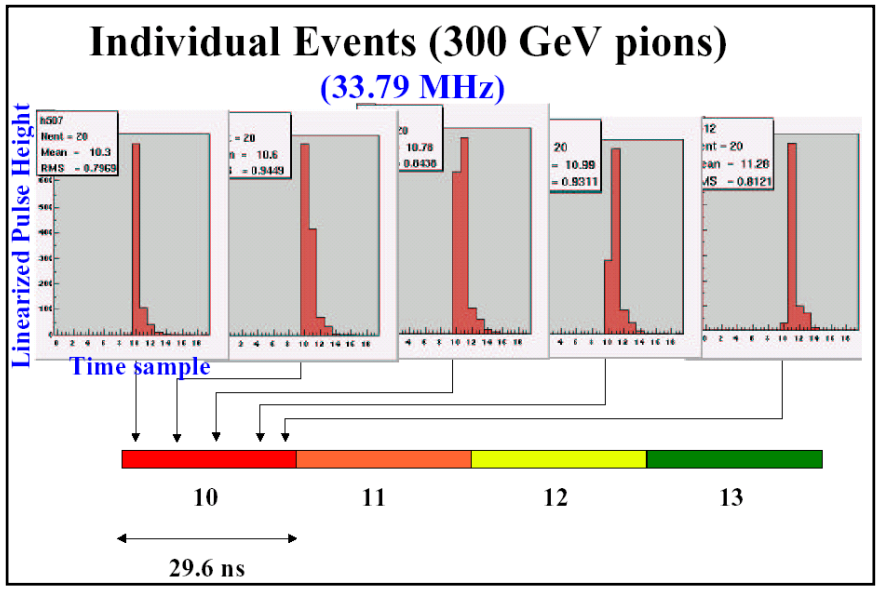
20 time slices at TB. (5~10 at CMS)

GeV/ADC


100 GeV electron data
GeV/QIE count (fC)
0.25
0.2
0.15
0.1
0.05
0
0
2
4
6
8
10
12
14
16
η
ϕ = 1
ϕ = 2
ϕ = 3
ϕ = 4
ϕ = 5
ϕ = 6
60MeV ~ 240MeV / 1 ADC count
→ 0.6TeV ~ 2.4TeV / Full range (1 time slice)
→ 1.2TeV ~ 4.8TeV / Full range (2 time slices)

Adjust HPD Gain

1. Change HV to adjust gain.
2. Put lower gain HPDs in HE



For 3TeV

1 time slice : 300MeV/ADC, noise=270MeV

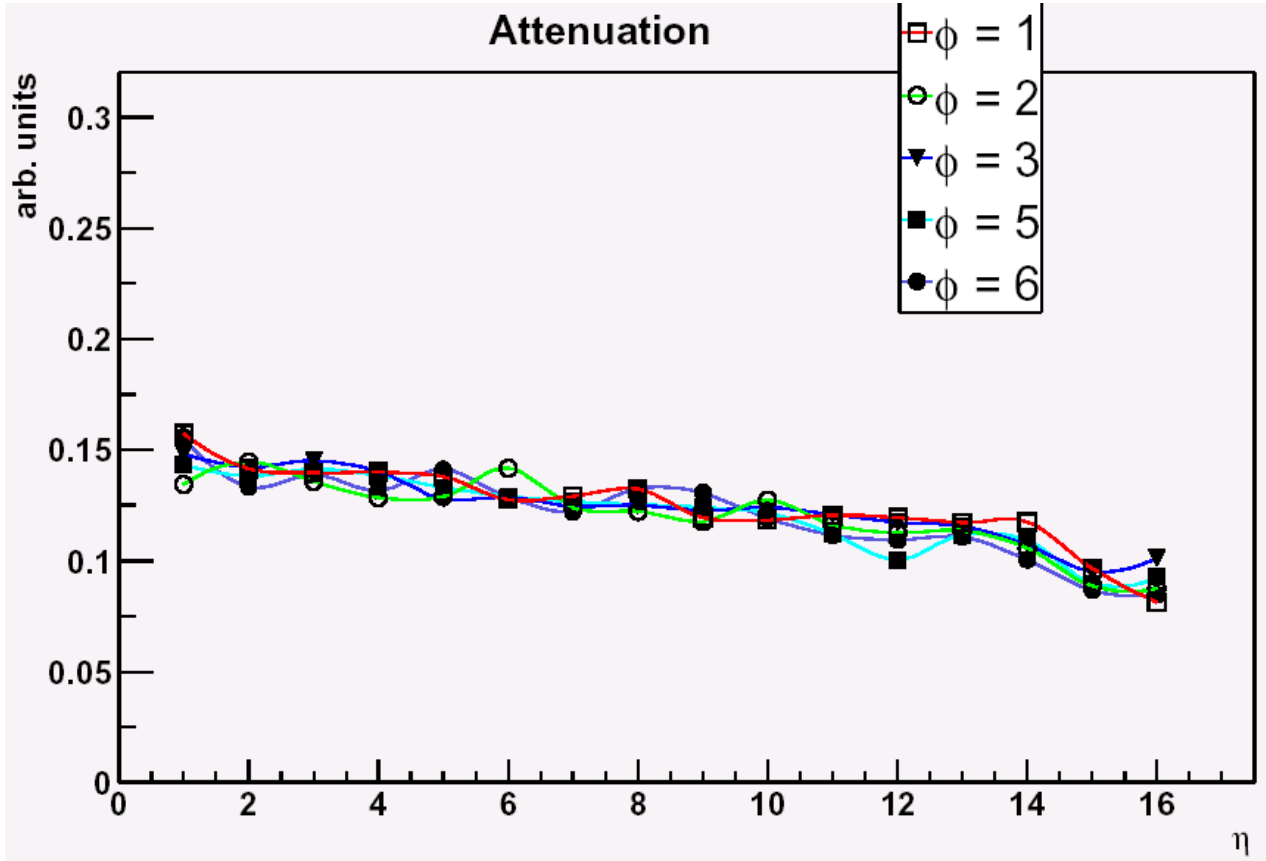
2 time slices: 150MeV/ADC, noise=212MeV

200	280
250	350

Eta dependence attenuation

Variation in eta

Eta	1/attenuation
1	1
2	0.947
3	0.947
4	0.918
5	0.904
6	0.887
7	0.847
8	0.862
9	0.831
10	0.825
11	0.786
12	0.756
13	0.769
14	0.730
15	0.618
16	0.605



2.5TeV …..
3.0TeV …..
4.1TeV …..

1.8TeV
2.2TeV
3.0TeV

Pulse Shape

Pulse Shape Simulation

(S.Abdullin)

- **Scintillator + wave-length shifter**

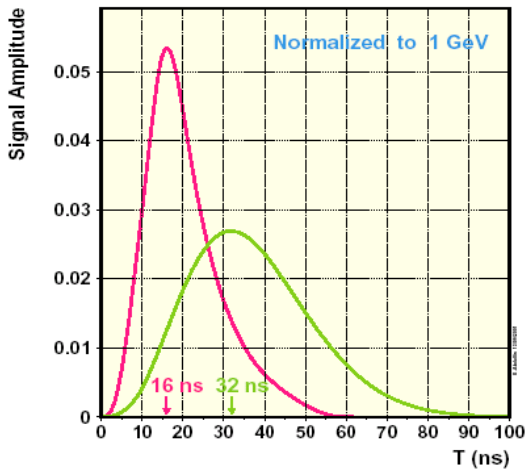
  $f_d(t) = \exp(-t/\tau_s)$, $\tau_s = 10$ ns

- **HPD**

  $f_{HPD}(t) = 1.0 + (t/\tau_{HPD})$, $\tau_{HPD} = 12$ ns

- **Preamplifier**

  $f_p(t) = t * \exp(-t/\tau_p)$, $\tau_p = 5$ ns



- **Scintillator + wave-length shifter**

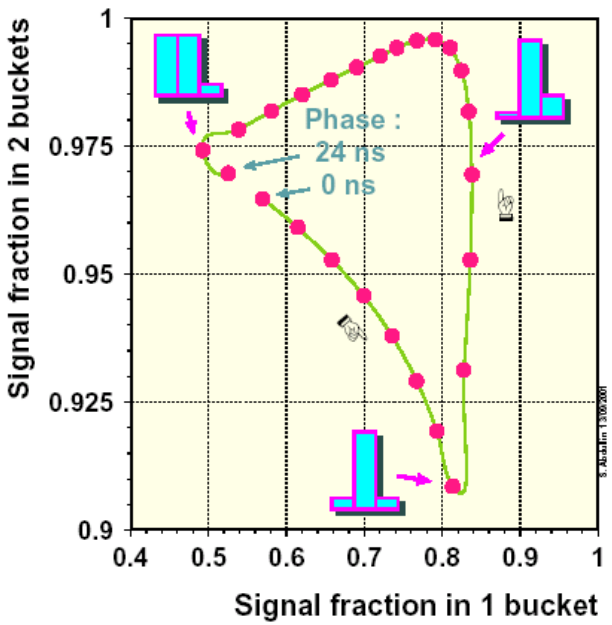
  $f_d(t) = \exp(-t/\tau_s)$, $\tau_s = 11$ ns

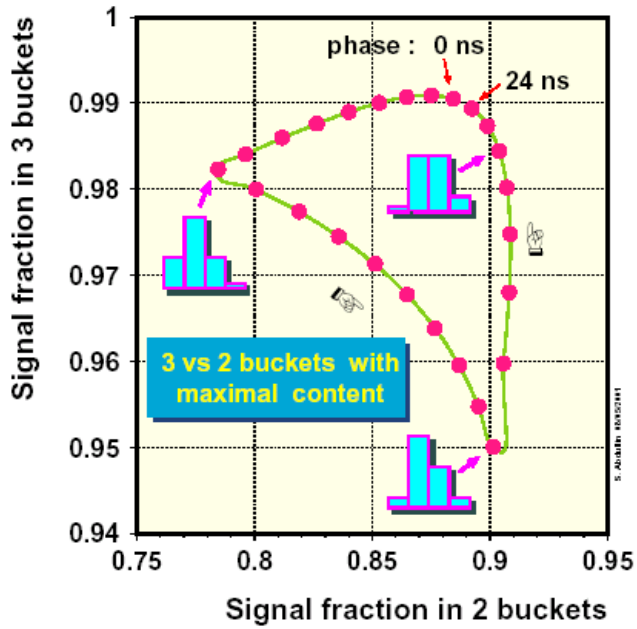
- **HPD**

  $f_{HPD}(t) = 1.0 + (t/\tau_{HPD})$, $\tau_{HPD} = 10$ ns

- **Preamplifier**

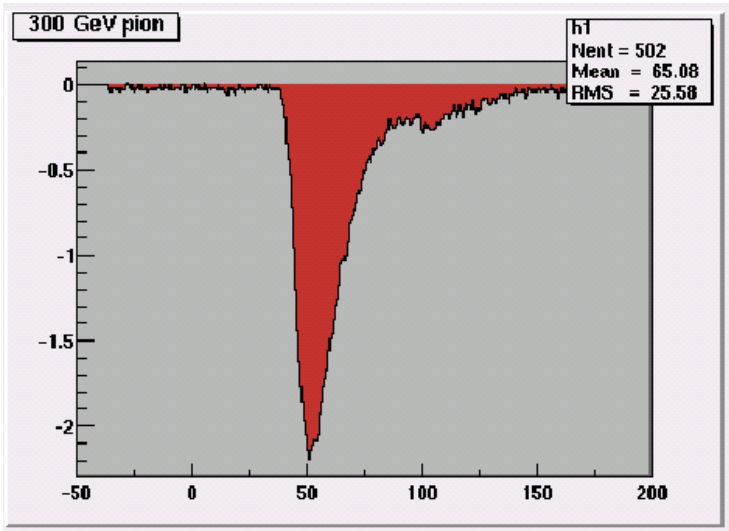
  $f_p(t) = t * \exp(-t/\tau_p)$, $\tau_p = 25$ ns

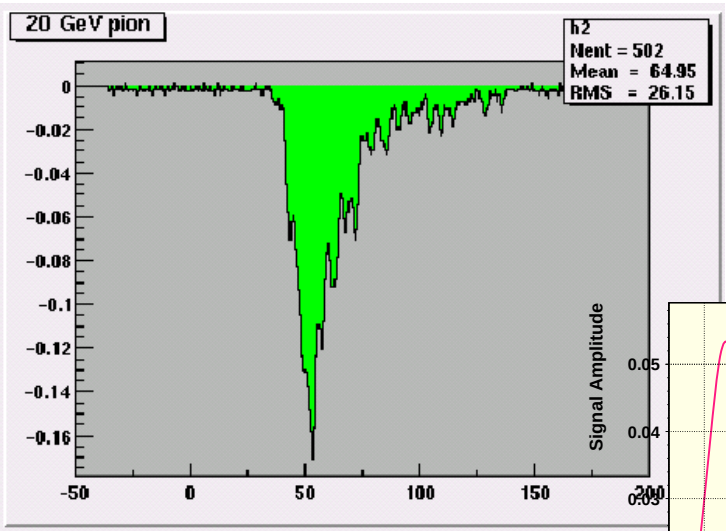


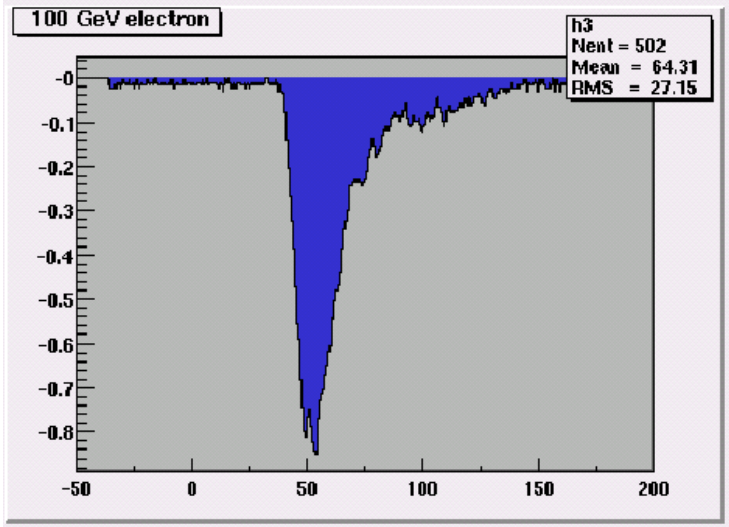


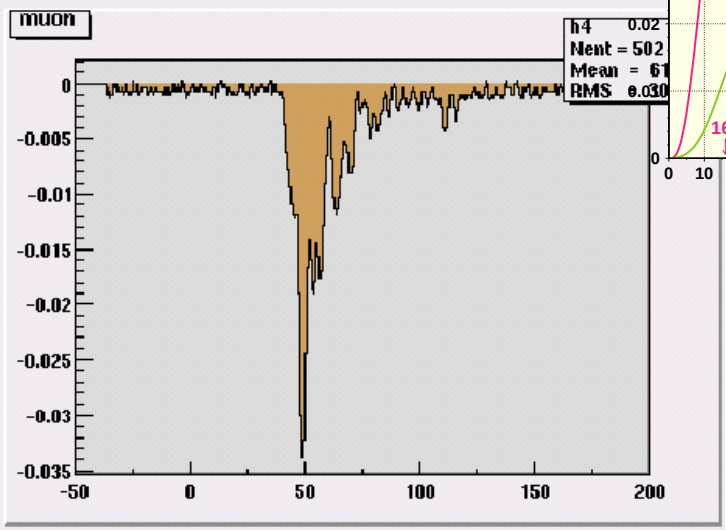
Scope Measurement with PM

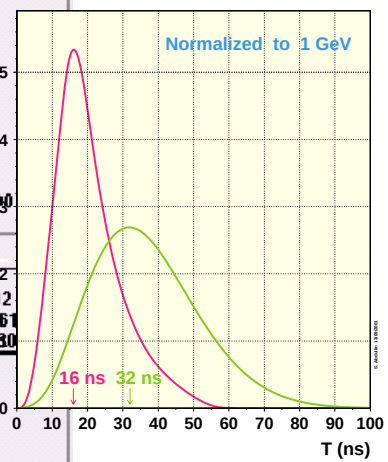
(Elias/Rohf)

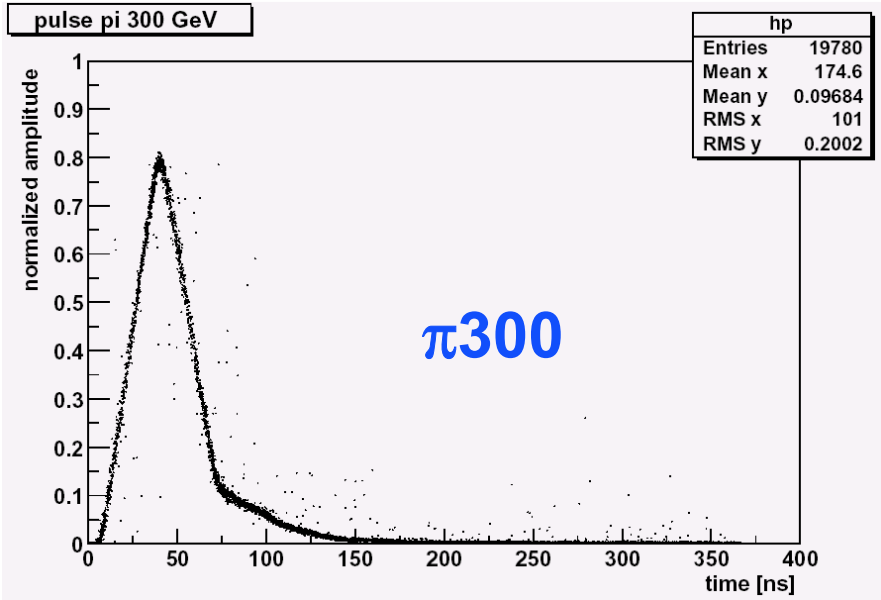


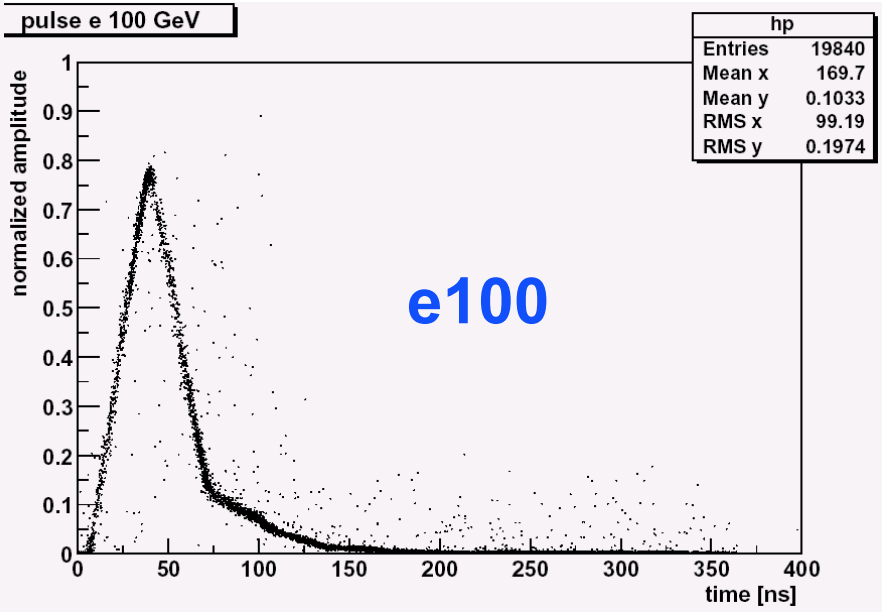




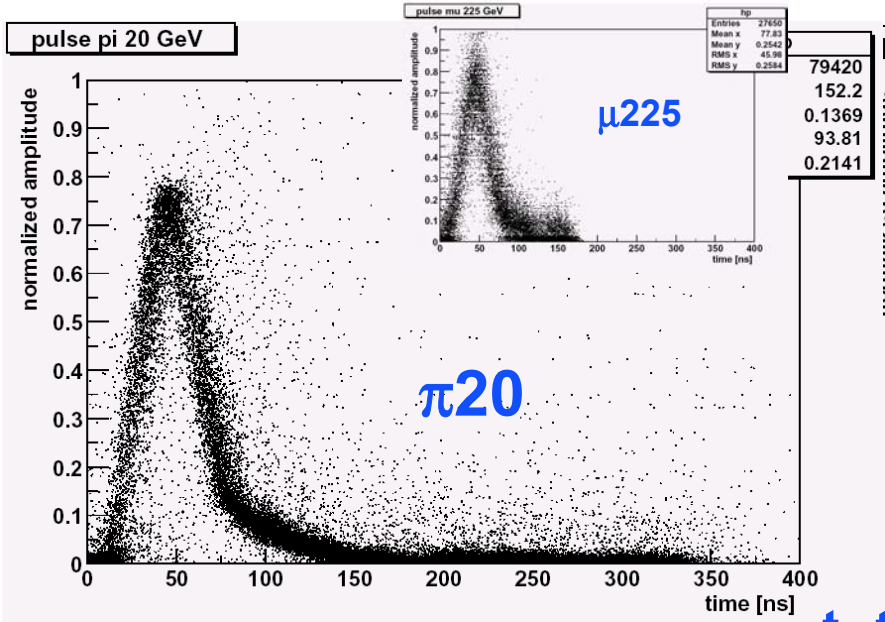


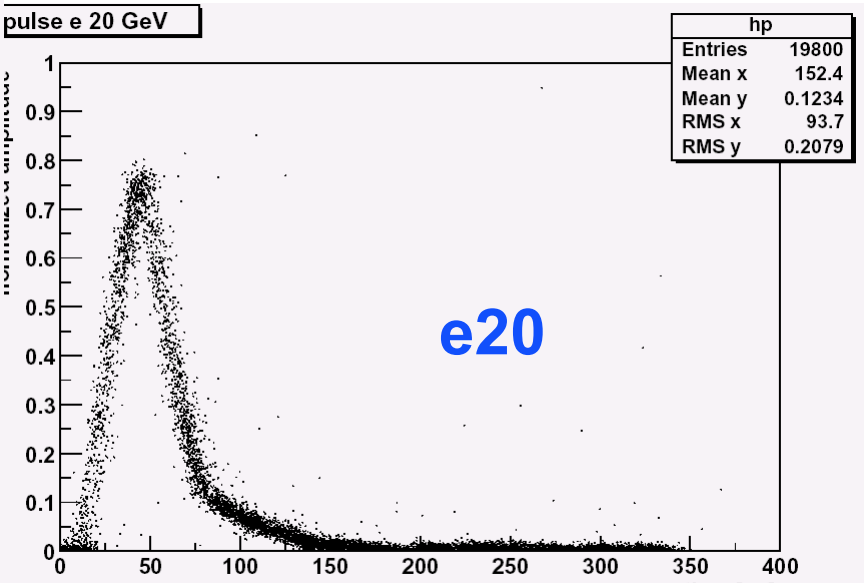






E_i/E_{all}





(Damgov)

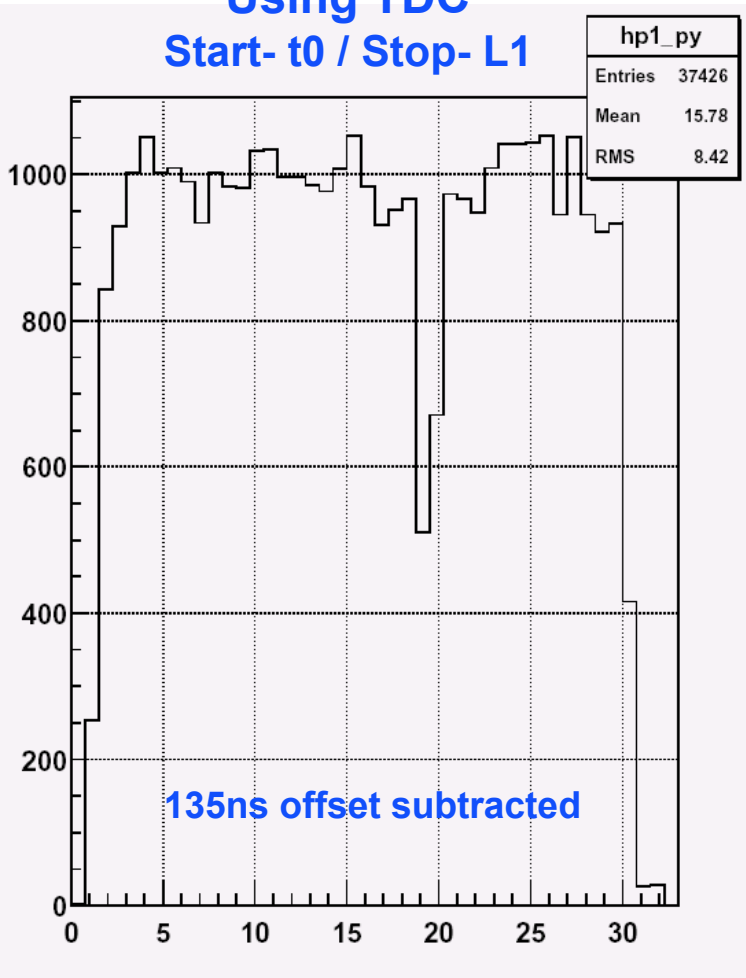
t_i-ts_{mean}

Need correction for 25ns/30ns!

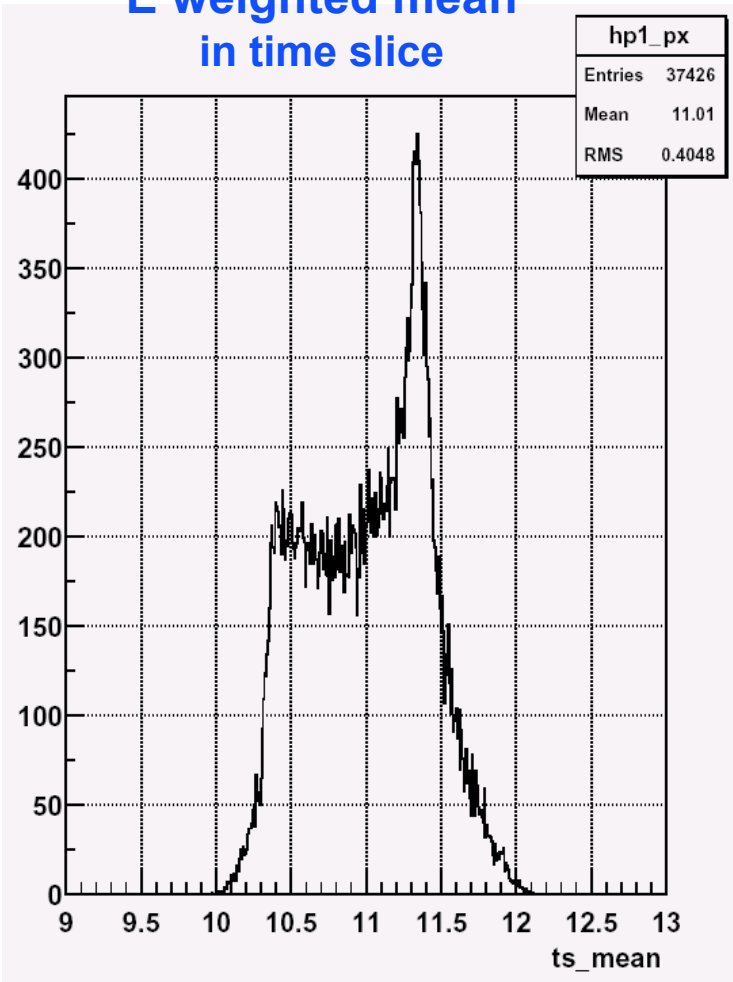
Two Phase Measurements

Run 3236, 300GeV pion, E(HC)>100GeV

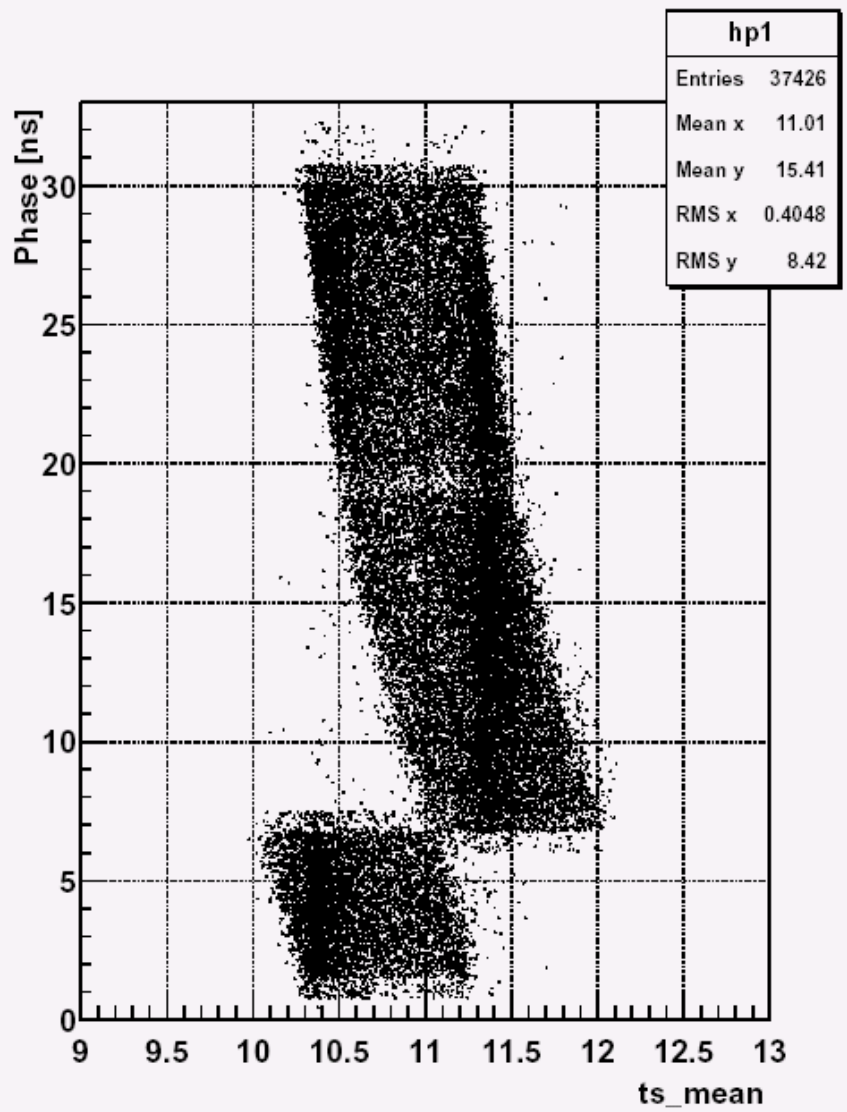
Using TDC
Start- t0 / Stop- L1



E weighted mean
in time slice



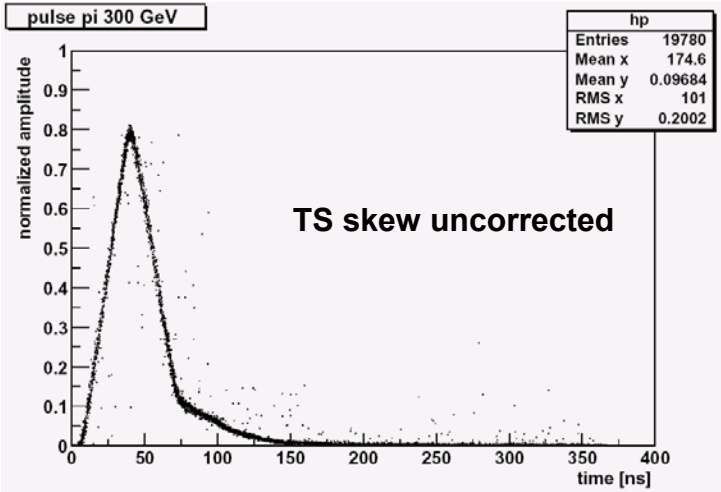
Phase (TDC) vs TS-mean

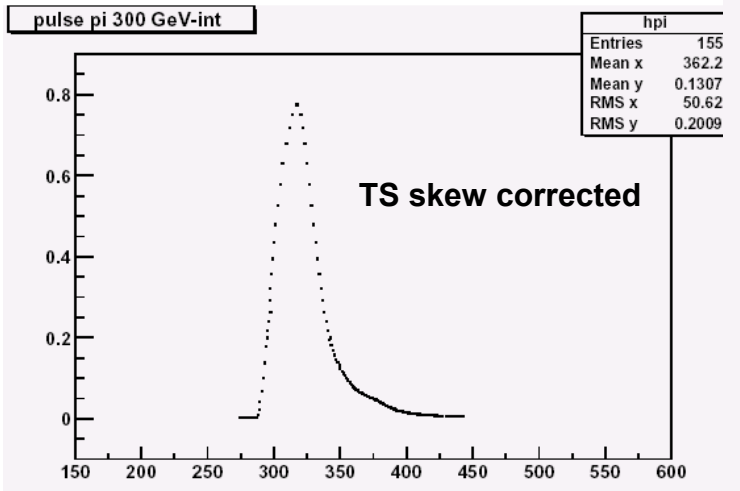


1 time slice wide
at a given phase.
… ???

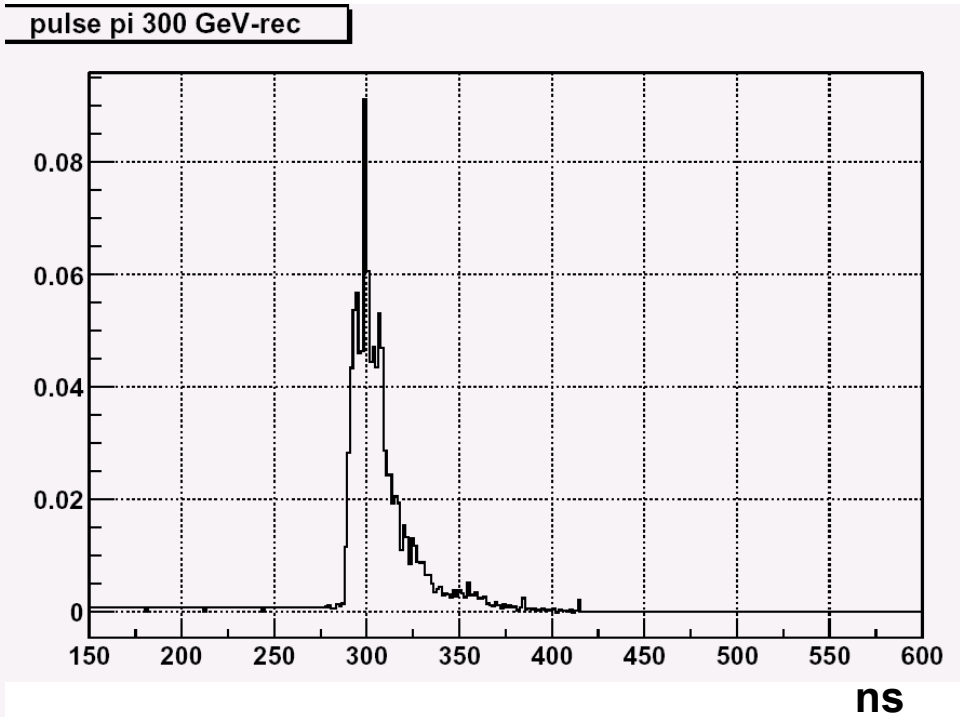
Pulse Shape

E in 30ns time slices

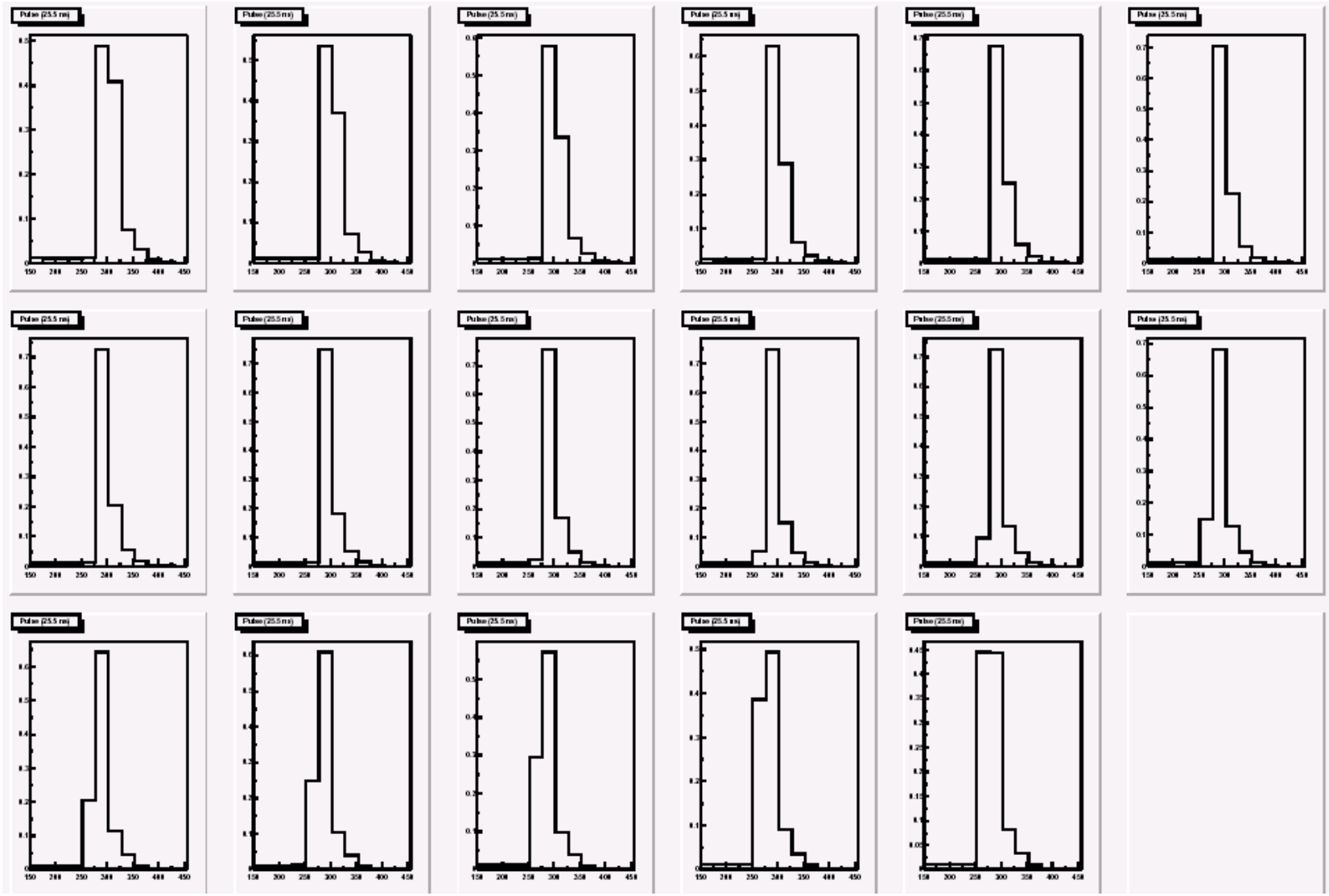




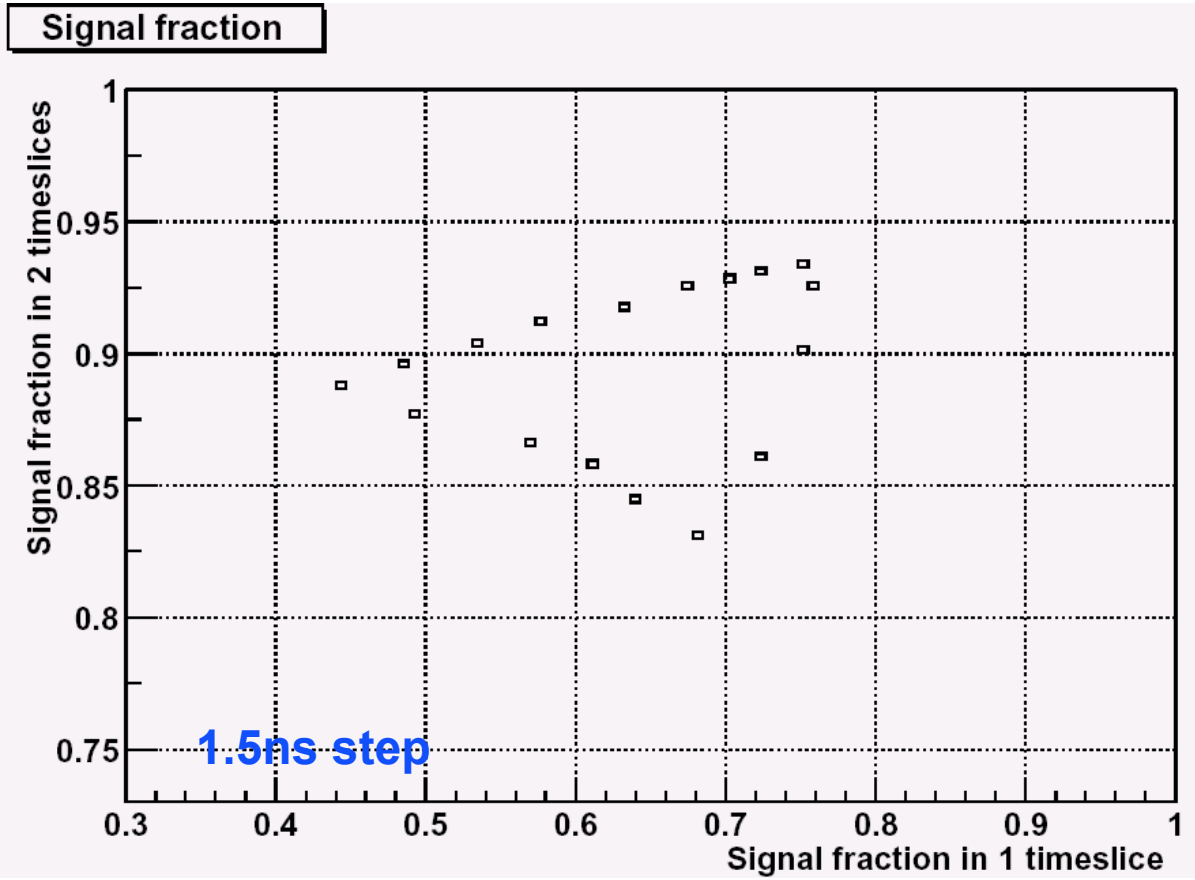
Reconstructed pulse shape



Signal in 25ns Time Slices



Energy Collection

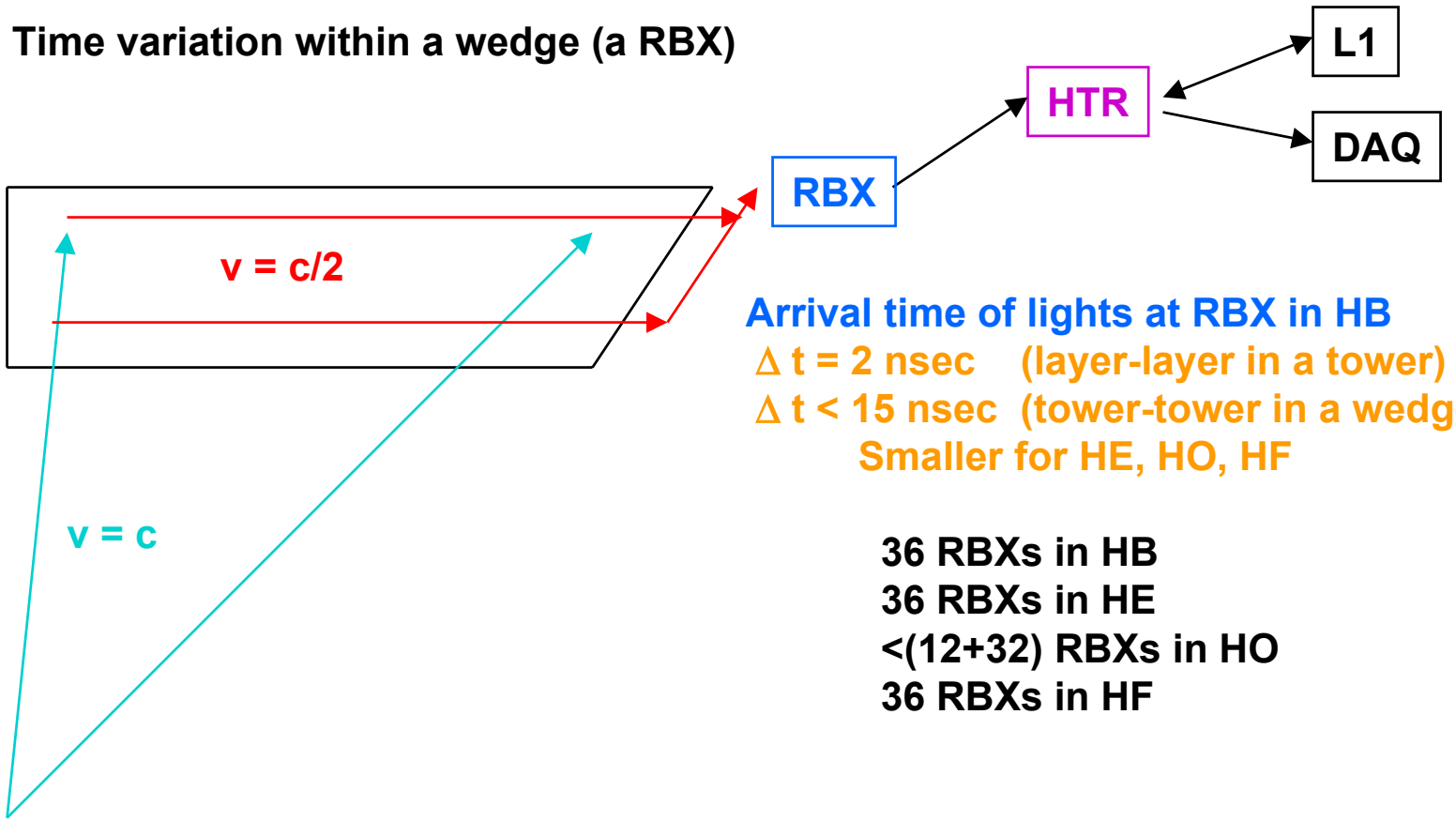


Variation 2% (5%)
1 TS- 3ns (6ns)
2 TS- 6ns (12ns)

Eta dependence timing

HCAL Timing Calibration

1) Time variation within a wedge (a RBX)



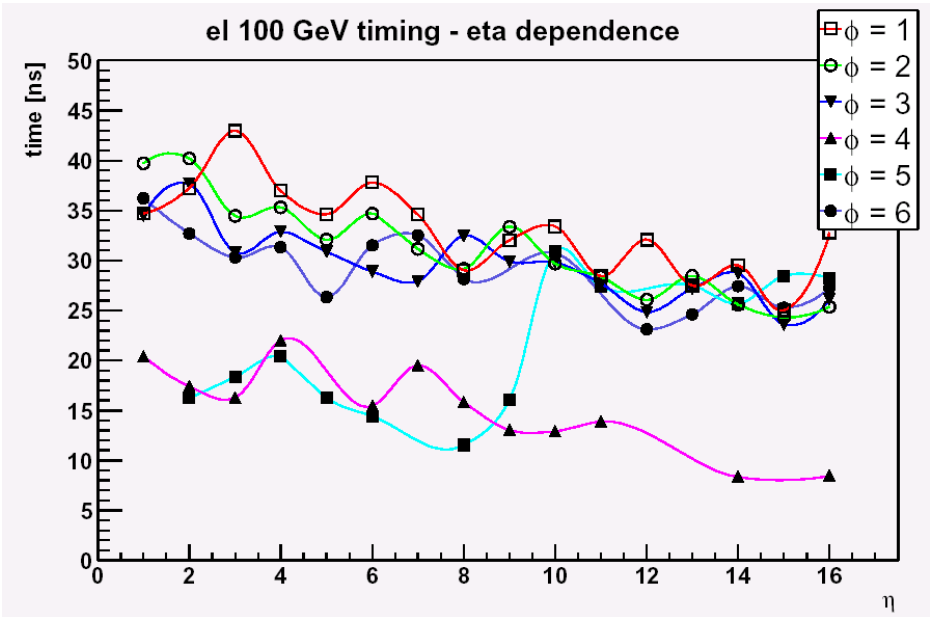
Arrival time of lights at RBX in HB
$\Delta t = 2$ nsec (layer-layer in a tower)
$\Delta t < 15$ nsec (tower-tower in a wedge)
Smaller for HE, HO, HF

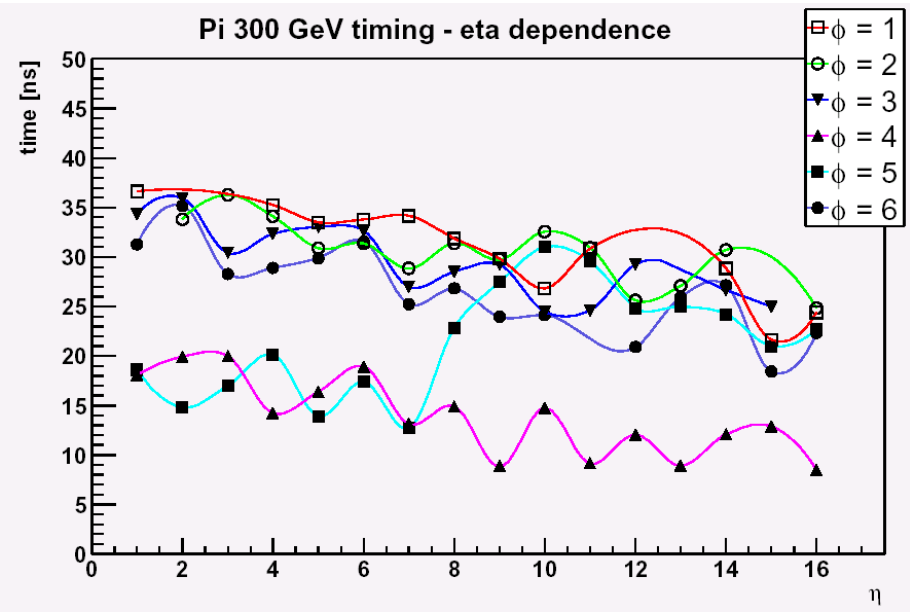
36 RBXs in HB
36 RBXs in HE
<(12+32) RBXs in HO
36 RBXs in HF

2) Synchronization (global)
L1 data, L1 accept (pointer to pipeline), 40MHz clock

eta dependence timing

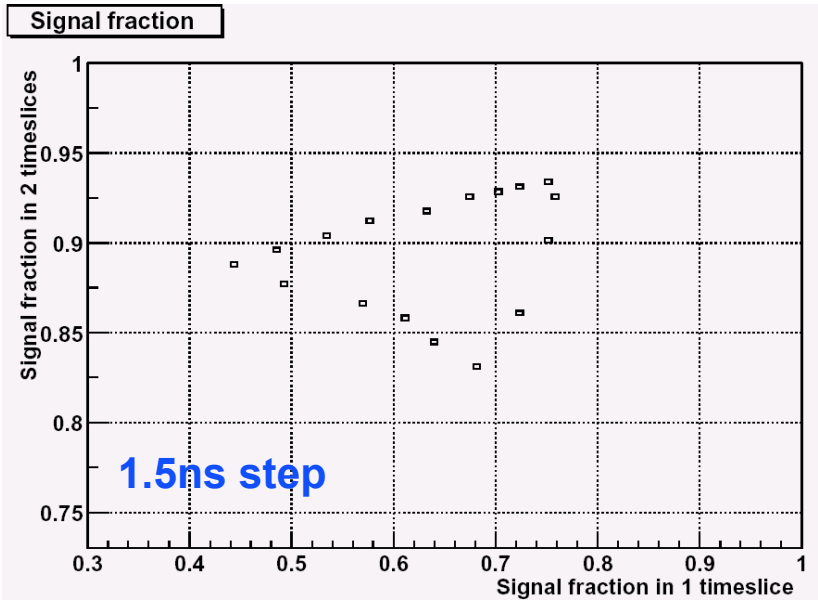
Calculated using corrected TS mean.





~10ns spread in eta 0 – 16

Time Correction in and among RBX



Variation 2% (5%)
1 TS- 3ns (6ns)
2 TS- 6ns (12ns)

QIE clock control ASIC

clock skewing by 1ns
over 25ns

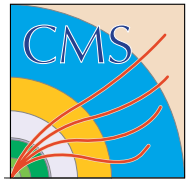
Method

initial variation ~10ns
in hardware construction.

- Laser pulse to all tiles (20Hz).

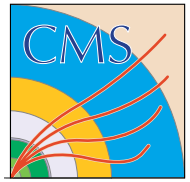
- Monitor by reading out 5 time slices and histograming the sharing fractions.

Adjust individual
timing to accuracy = 2~4 nsec.



HO for Muon Trigger

See Banerjee/Rohf's talk



Layer 0

Layer 0

Goal:
1. **Overweight 1.5 or 3.0?**
2. **Demonstrate how to implement.**

TB 1996 and MC indicated ~1.5!

Wt ~ 1.0
Implemented!

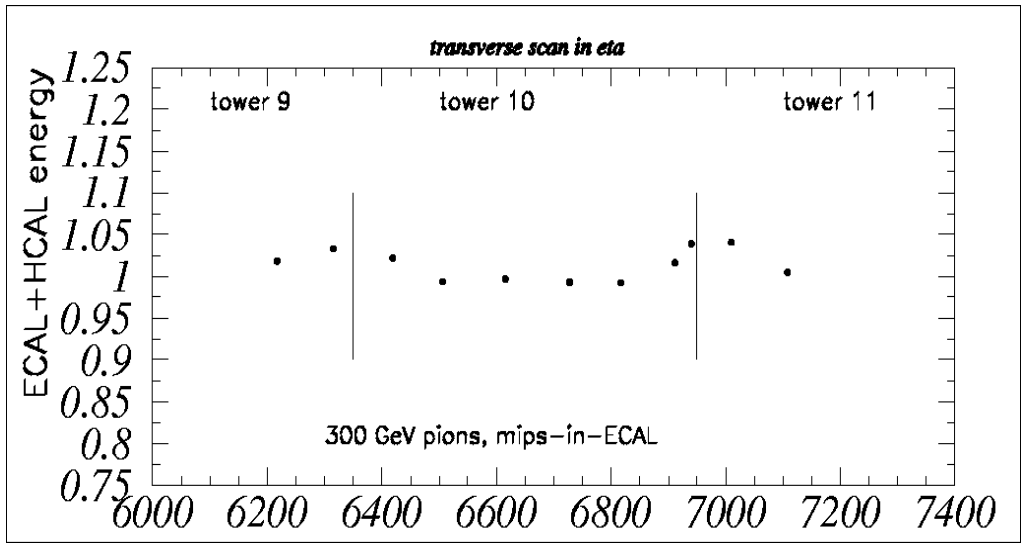
(de Barbaro)

Need real ECAL super module to determine final weight.

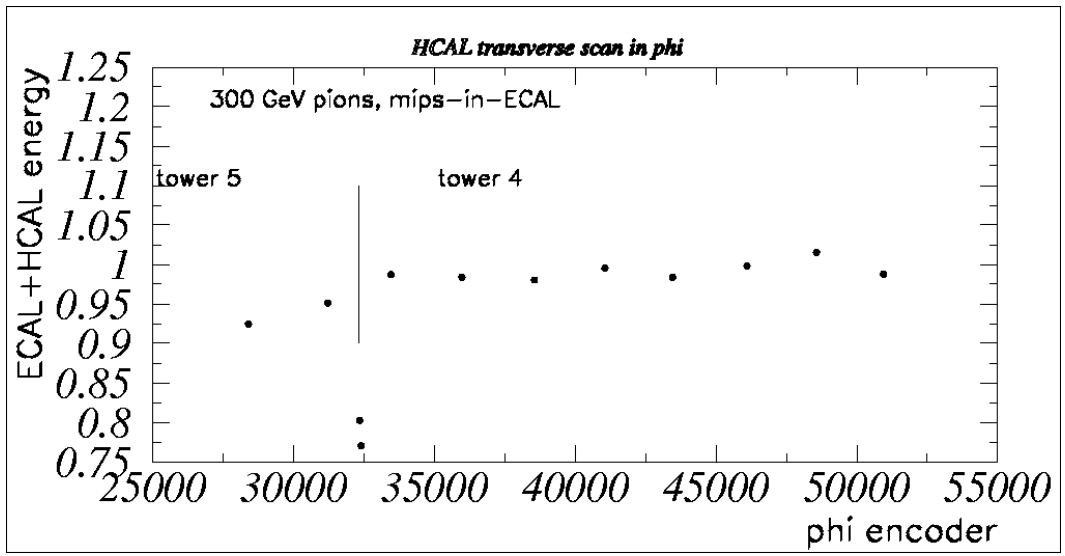
Crack Scan

Crack/Tower Scans for HCAL

Eta scan



Phi scan

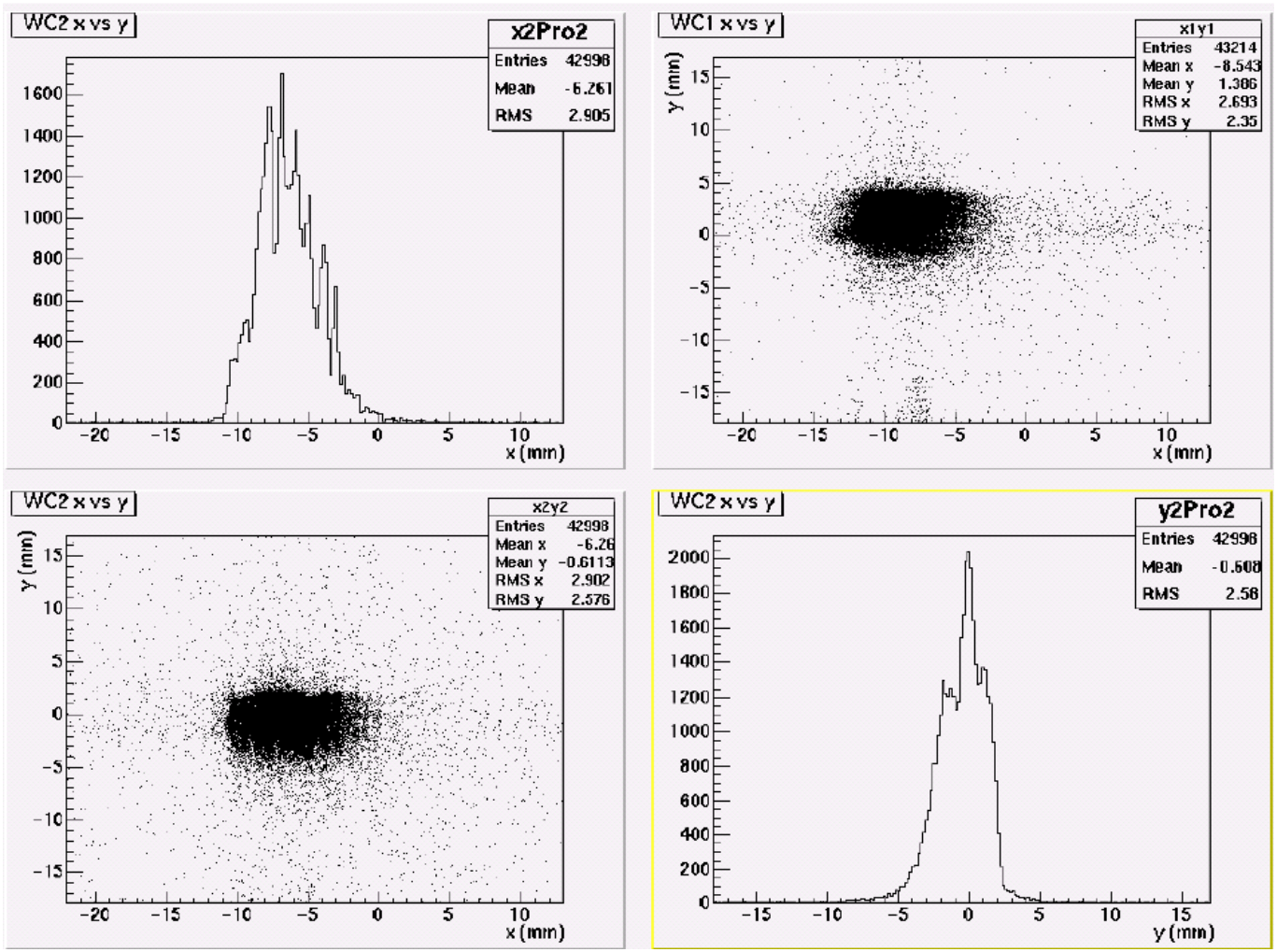


(P. de Barbaro)

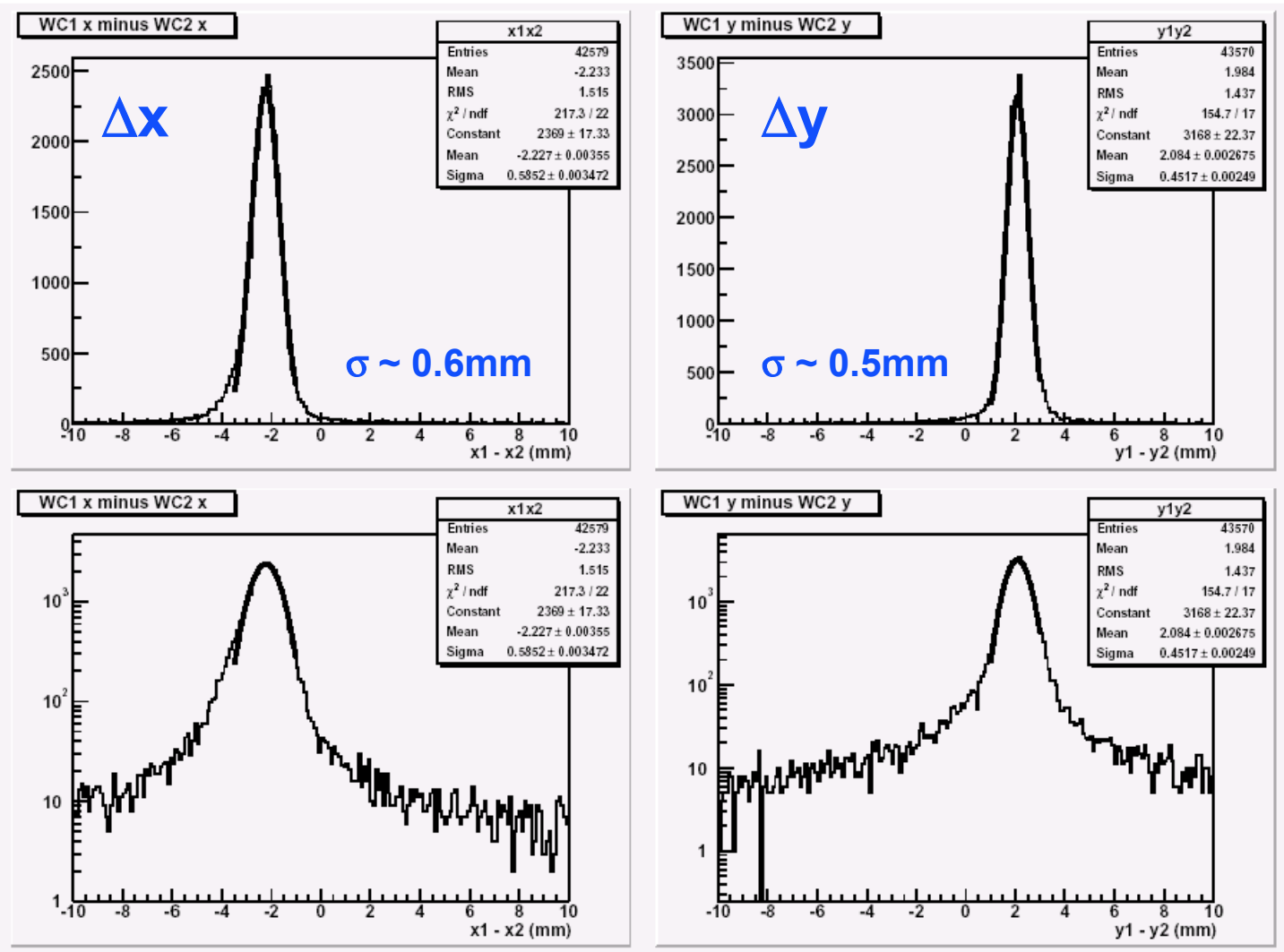
Wire Chamber

(R.Vidal)

Wire chamber data useful after Run 2698.



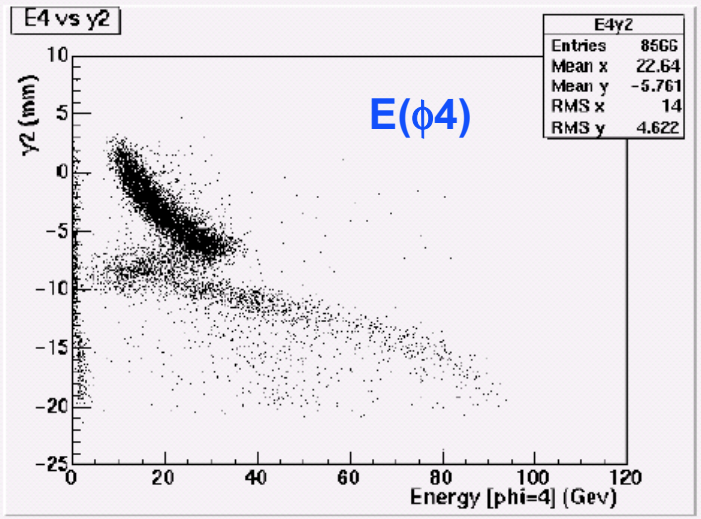
W1-W2

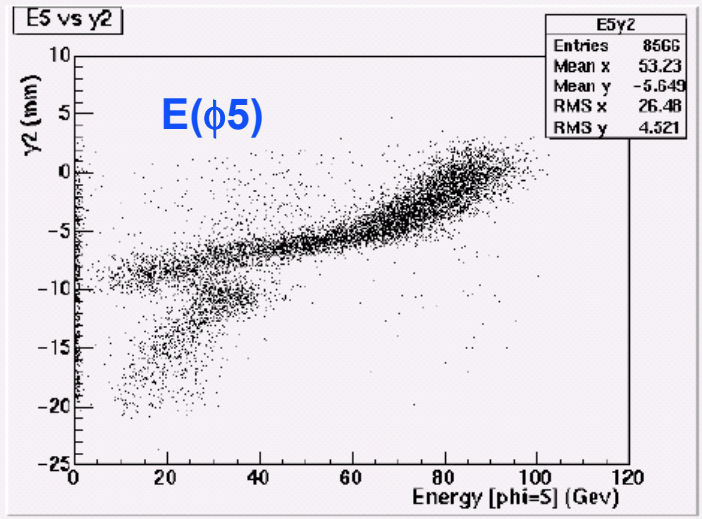


Ready for gap study!

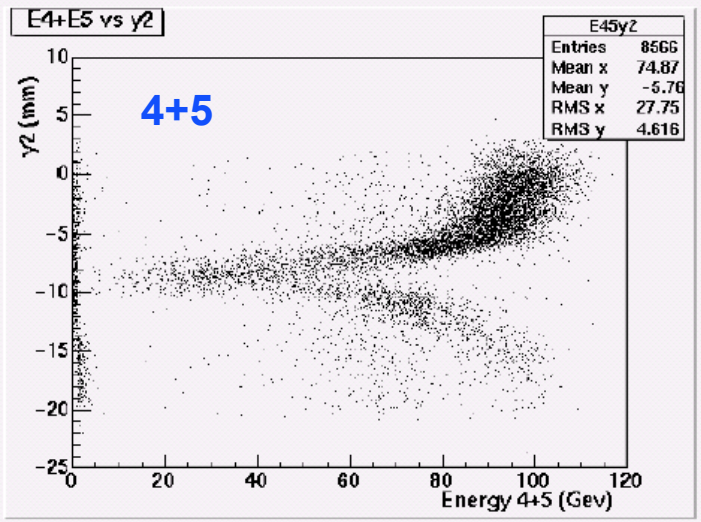
Crack between Wedges 100GeV electron

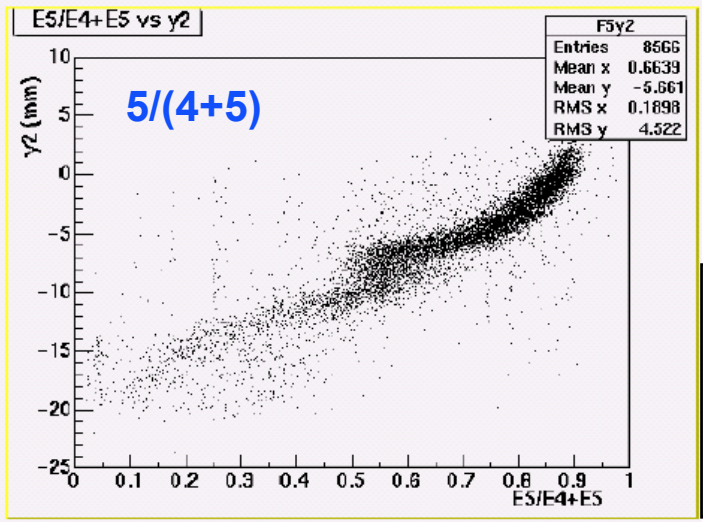
Y2 (mm)





Y2(mm)





air gap:
a few mm

put in MC

(Rick Vidal)

HB TB 2003
(my suggestion)

Goal:

- **Repeat TB2002 goal**
- **Local synchronization. (time in all channels.)**
- **Operation of full calibration system, including laser.**
- **Generation of L1 primitive**
  - Pedestal subtraction / gain correction / E to Et conversion / BX id (?)
- **Remote monitoring and analysis.**

Preparation: (addition to tasks obvious to get the goal)

- **Before the TB period**
  - HPD calibration (all) – QE
  - QIE calibration (all) – gain in full range for each CapID
  - Source calibration
- **E-log book.**

HB Testbeam 2002

Goals (HB):

- Demonstrate 144ch working
- Demonstrate DCS going
- Source data vs GeV/ADC (beam: e / μ / π)
- Muon signal in HO for muon trigger
- Eta dependence (attenuation)
- Eta dependence (timing)
- Pulse shape (needs TDC)
- Weight in Layer 0

→start construction of Calibration Database

Additional Goals (left over from 1999TB)

- Crack between wedges
- e/pi (resolution and linearity) ←
- Cerenkov light in clear fibers ←

Conclusion

QIE dynamic range.

- Not much head room for different input (HPD) gain.
- Need to control input gian by changing HPD HV.

QIE calibration

- Need to calibrate pedestal and gain (full range) for each CapID.

Source calibration

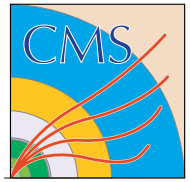
- Need to calculate constants for each CapID (and then average over 4 CapID)
- May require higher statistics (because of 4 caps and noise).

TB data analysis.

- Extract results for all defined goals.
- Finish by March 2003, and publish.

TB 2003

- New goals are suggested.

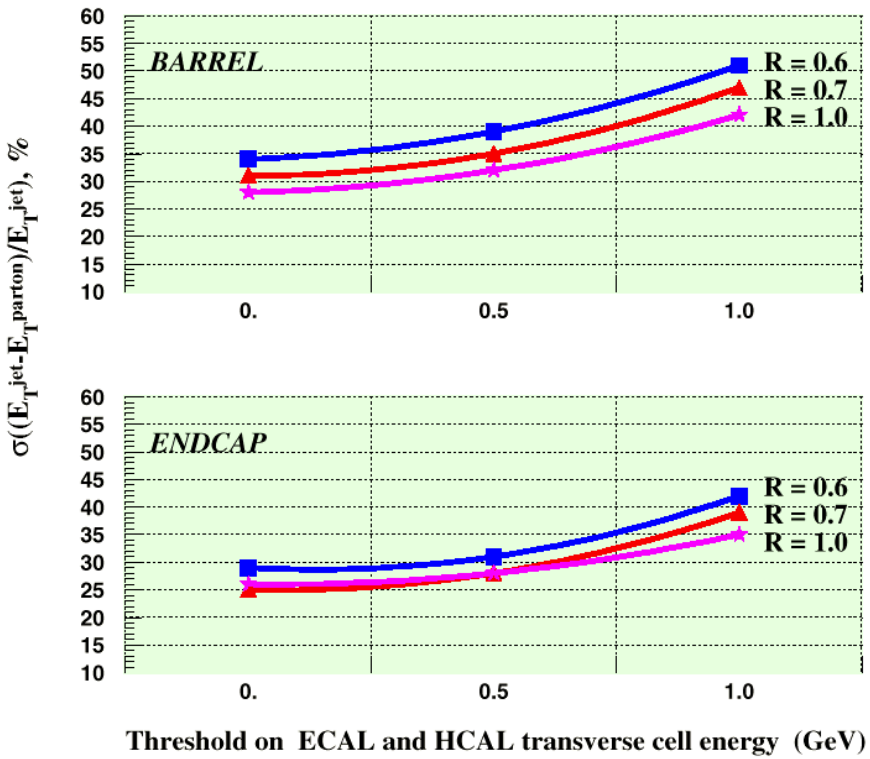


Additional

Effect of Threshold on low E_T jet and MET

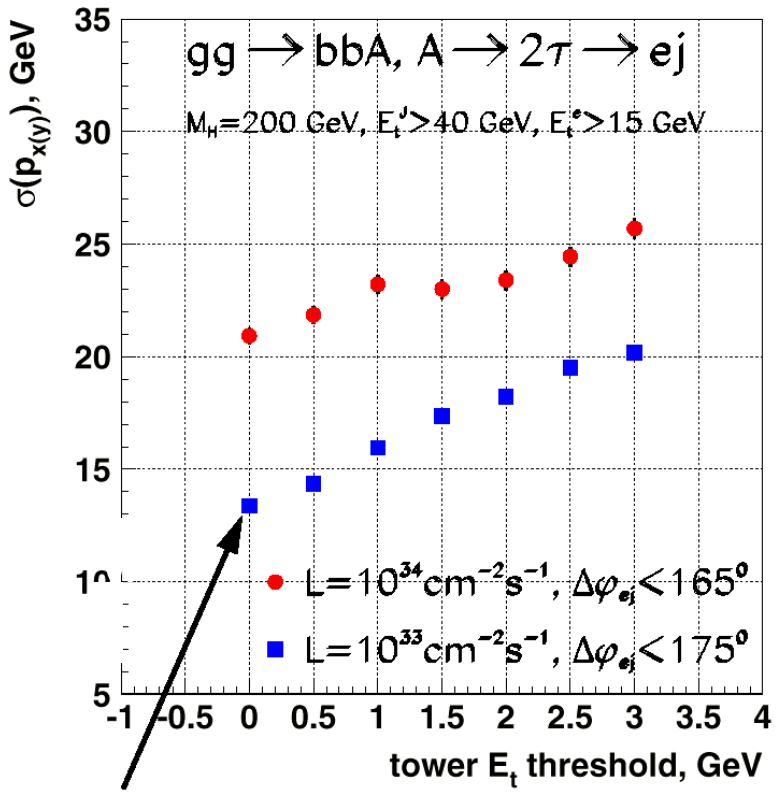
(SK Dec 2001)

20GeV parton jet @ 10E34



(I.Vardanian)

MET



(S.Nikitenko)

Lower threshold is better!

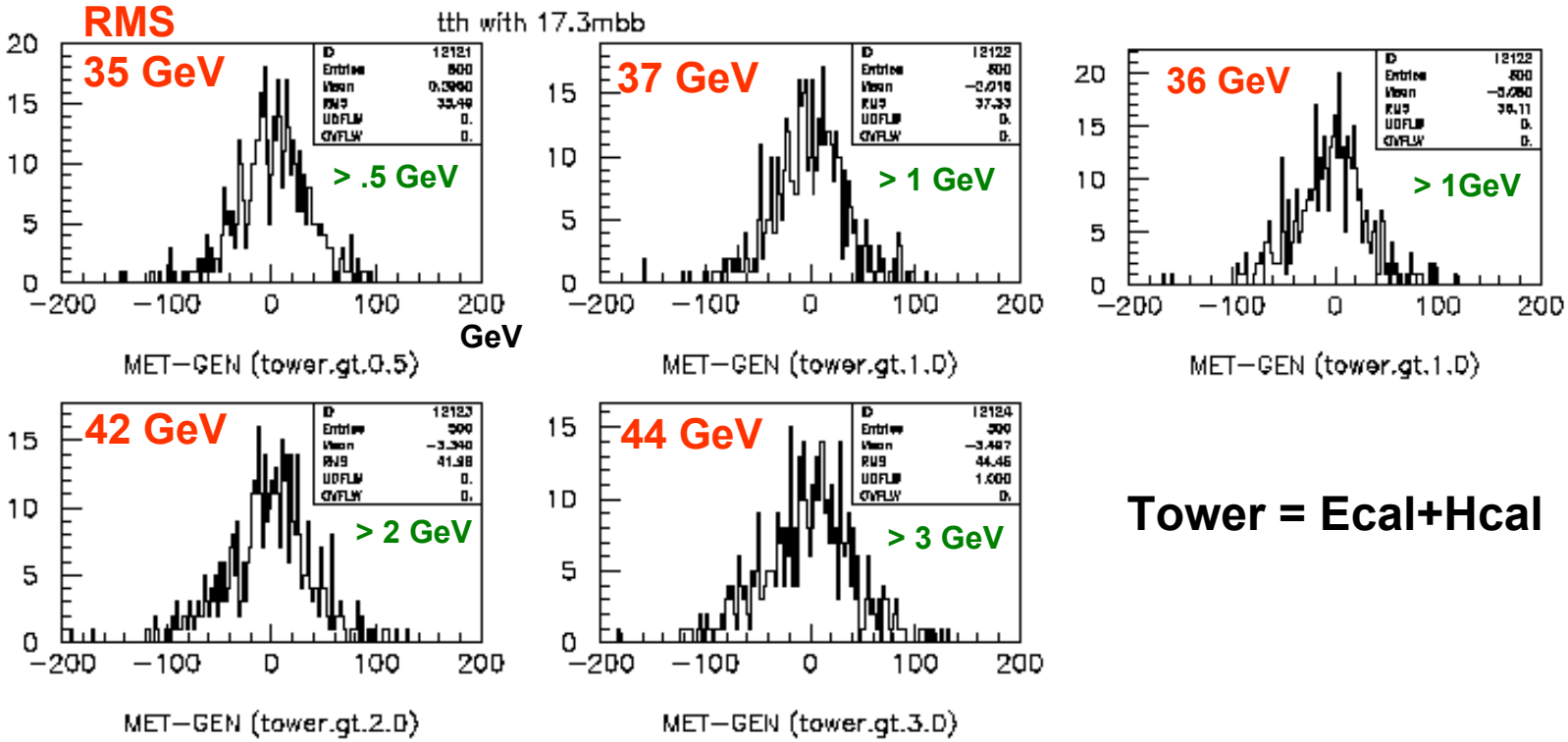
Electronics noise and occupancy define the threshold.
>> aim at 0.5GeV/tower @ 10E34

MET for Signal Events with Pile-up and Tower Threshold

(SK June 2000)

With 17.3 min-bias events

No min-bias



Tower = Ecal+Hcal

>> Not much pile-up effect with this resolution!

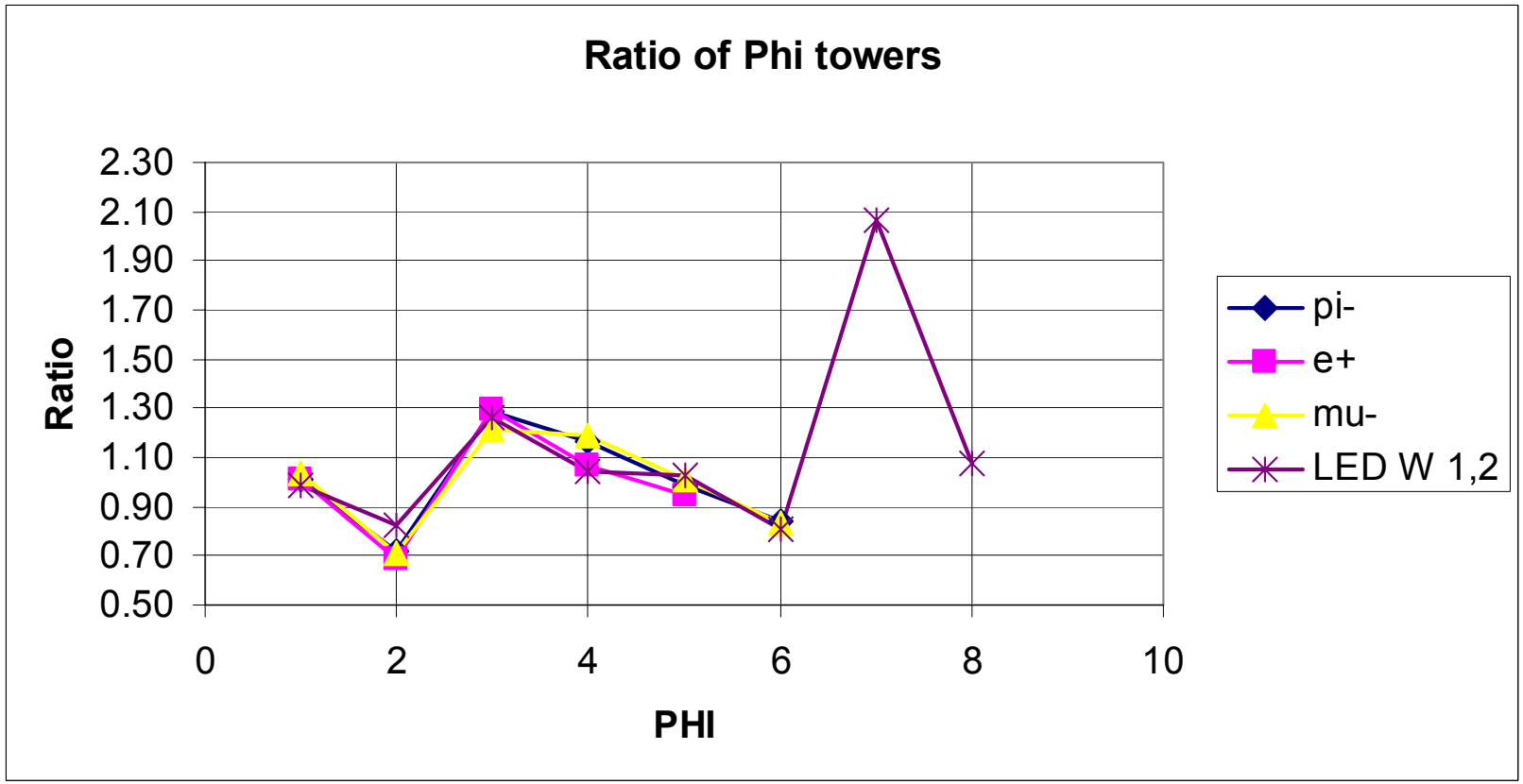
>> Resolution gets worse as threshold increase.

E in single HCAL readout

>3TeV jets 2.9fb → 290 events/year at 10E34.

		Fraction of events above E threshold (%)					
QCD bins	MC evts	1.5TeV	2.0TeV	2.5TeV	3.0TeV	3.5TeV	4.0TeV
80-120	1000	1.40	0.60	0.30	0.00	0.00	0.00
2600-3000	2000	16.65	3.55	0.70	0.20	0.05	0.00
3000-3500	2000	28.85	7.40	1.75	0.30	0.10	0.05
3500-4000	2000	46.05	18.15	5.70	0.90	0.15	0.00
4500-5500	50	64.0	46.00	20.00	6.00	4.00	0.00

Need to cover up to 3TeV? YES.

(J.Damgov)

Source/LED-Laser/Beam